

THE SYSTEMATICS OF THE *EREMOBATES SCABER* SPECIES-GROUP (SOLIFUGAE, EREMObATIDAE)

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ABSTRACT. The scaber group of the genus *Eremobates* is reviewed in terms of new characters and a more restricted biogeographic area. Three new species are described from the U.S.A.: *Eremobates socal* (California), *E. icenoglei* (California), *E. corpink* (Utah). We synonymize *E. gladiolus* Muma with *E. scaber* (Kraepelin); *E. consors* Muma, *E. ascopulatus* Muma and *E. flavus* with *E. ascopulatus* Muma; and *E. mimbrenus* Muma with *E. mormonus* (Roewer). *Eremobates scaber*, *E. hodai* Muma, *E. clarus* Muma, *E. similis* Muma are now described from both sexes. All scaber species except the Mexican species, *E. legalis* Harvey, are now known from both sexes. We also present the first phylogeny of the species group based on morphological characters. This phylogeny demonstrates a geographic grouping into northern and southern clades.

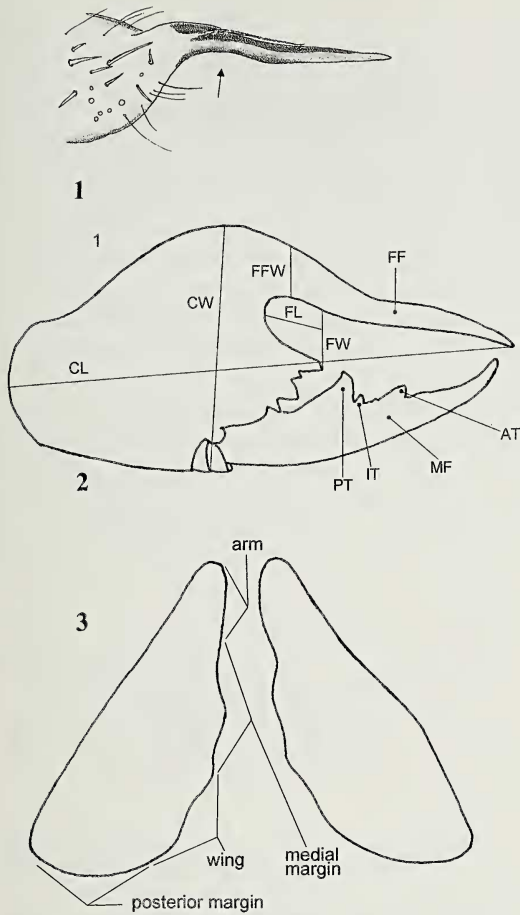
Keywords: Solifugids, phylogeny, cladistic analysis, biogeography

Muma (1951) redescribed the genus *Eremobates* Banks 1900 to include those solifugid species characterized by males with a basally dilated mesoventral groove running the length of the mesodorsal or mesoventral surface of the fixed finger. The male flagellum complex consists of dorsal striate setae, ventral striate setae, and a flattened apical plumose seta covering much of the mesoventral groove. The female genital opercula varied depending upon the species-group. Additionally the *Eremobates scaber* species group was erected by Muma (1951) to include those *Eremobates* whose males were characterized by a broad basal notch occupying one-third or more of the length of the fixed finger in dorsal view (Fig. 1). In the scaber group the mesoventral groove is deep and narrow. The female genital opercula are roughly triangular with species distinguished by differences in the medial margins.

Muma (1951) listed six species in the scaber group including the typical or defining species *E. scaber* (Kraepelin 1899) although he had not seen the female type specimen. After examining type specimens in both the U.S. and Europe as well as other specimens from various collections and collectors Muma (1970) recalled Kraepelin's 1899 description of *Datames scaber* based on the female type

from "Washington Territory" as the correct characterization of *Eremobates scaber*. He used his 1951 description, erroneously attributed to *E. scaber*, to establish *E. septentrionis* Muma 1970, used his 1951 description of *E. geniculatus* to erect *E. mormonus* (Roewer 1934) and defined *E. geniculatus* (C.L. Koch 1842) (Simon 1879, misidentified) using Simon's 1879 description of a single female from Mexico (Muma 1970). In 1989 Muma described six new species. This resulted in 15 species in the scaber group with *E. scaber*, *E. actenidia* Muma 1988, *E. clarus* Muma 1989, *E. consors* Muma 1989, *E. ascopulatus* Muma 1951 and *E. hodai* Muma 1989 described from only one sex although Muma included the male of *E. scaber* in the key. *Eremobates clarus*, *E. actenidia* and *E. consors* were each described from a single specimen and *E. ascopulatus* from two males. *Eremobates similis* (Muma 1951) was noted as being described in both sexes (Muma 1989), but the female description has not been found.

In describing *E. scaber*, Muma (1951) used specimens from an area that extended from the northwestern United States to Las Vegas, Nevada but noted that it might include other species of this group. In addition, other species of this group seemed to have sympatric ranges (Muma 1951, 1962, 1989). In each of



Figures 1–3.—Diagnostics used in compiling data for scaber group. 1. *Eremobates scaber*, dorsal view of male fixed finger (arrow identifies basal notch). 2. Diagram of male chelicera showing ranges of measurement and morphological characters: CL = cheliceral length, CW = cheliceral width, FL = fond length, FW = fond width, FFW = fixed finger width, FF = fixed finger, MF = movable finger, PT = primary tooth, IT = intermediate tooth, AT = anterior tooth. 3. Diagram of female genital operculum.

his publications Muma (1951, 1962, 1989) cited several problems with the distinction between species and problems of sympatric associations. Muma (pers. comm.) indicated that this group needed to be more thoroughly studied.

For the most part, this group is an inhabitant of piñon pine-juniper or desert shrub communities. Muma (1963) identified *E. zinni* (Muma 1951), *E. similis*, *E. ctenidiellus* and *E. mormonus* as inhabitants of the Mercury, Nevada Nuclear Test Site, a Mojave Desert

region, although some of the specimens were misidentified. Allred & Muma (1971) listed *E. septentrionis* and *E. ctenidiellus* as inhabitants of the Snake River Plain which is part of the Columbian Plateau. Brookhart (1972) found *E. mormonus*, later changed to *E. similis*, in the San Luis Valley of Colorado and *E. ctenidiellus* in the mesa regions of western Colorado. The Sevilleta Long Term Ecological Reserve project at the northern tip of the Chihuahuan Desert surveyed six distinct desert grassland/high desert areas and found *E. similis* in only the piñon-juniper association (Brookhart & Brantely 2000). At the Hanford Nuclear Site, Rich Zack's *E. scaber* material (WSU) was collected in Great Basin Desert shrub habitat, and various Canadian specimens were collected in the sagebrush of the Okanogon Valley. *Eremobates scaber* group species have been collected at 2394 m in Wyoming, 2303 m in the San Luis Valley of Colorado, and on Mt. Palomar, California.

Muma (1951, 1962, 1970, 1989) used length vs. width of the fondal notch, number and shape of ctenidia, and number of palpal papillae, as well as coloration of appendages to separate each species. The number of ctenidia ranged from 0–6. The palpal scopula varied from none to over 120 papillae. Females were identified by the structure of the genital operculum and the coloration of appendages. Coloration of eye tubercle and malleoli were noted but were consistently the same for all species with eye tubercles dark and malleoli white. Abdominal coloration varied from a pale yellow to a grey background dorsally and ventrally with lighter pleural membranes between species and also between specimens of the same species. Many specimens had tergites with a rectangular, brownish, violet pigmentation which gave the appearance of a broad stripe to many specimens. Muma (1951) calls this a sclerite although it is not particularly thick or hardened. It was not found to be diagnostic in this study.

Male chelicerae have no teeth on the fixed finger and some variation in the shape of the fixed finger in ectal view. The movable finger follows the general pattern of a large primary tooth, two intermediate teeth, the posterior being larger and an anterior tooth. The mesal tooth varies from tiny to absent. Female chelicerae have a fixed finger with teeth ordered successively posterior to anterior, intermedi-

ate tooth, large primary tooth, two intermediate teeth, medial tooth, a single intermediate tooth and a smaller anterior tooth. The female movable finger has a large primary tooth, a variable sized anterior tooth and two intermediate teeth, the posterior of which is larger. The mesal tooth varies from absent to medium size. Fondal teeth in both male and female grade out I, III, II, IV in size, although in some species the fondal tooth III is equal in size to fondal tooth I. Due to wear, the intermediate teeth on both male and female movable fingers are sometimes hard to diagnose.

METHODS

Because of their nocturnal habits solifugids are usually not collected in abundance and study specimens are difficult to obtain (Muma 1951, 1970, 1989; Punzo 1998). Efforts were made to accumulate at least five males and five females from identifiable geographical regions. The Sevilleta Long Term Ecological Research (LTER) site provided specimens over a seven year period (Brookhart & Brantley 2000) that enabled us to identify variations within an isolated species population. Brookhart conducted limited pitfall projects in the San Luis Valley, the northwest corner of Colorado near Dinosaur National Monument and the area around Colorado National Monument on the Colorado Plateau from 1997–1999. He also collected from southeast Utah using the same method during 2000–2001. A one year pitfall series from Hanford Site, Benton County, Washington collected by Rich Zack et al. was also examined. Collections from other institutions were also provided for study. We were able to examine all of the types. Coordinates for some specimens are approximate as they are based on historical locale information. We determined collection coordinates for specimens post hoc when possible. However, if the specimen was collected 6 km or more from the given site, the coordinates were not reported since the locale information on the collection label was considered too vague.

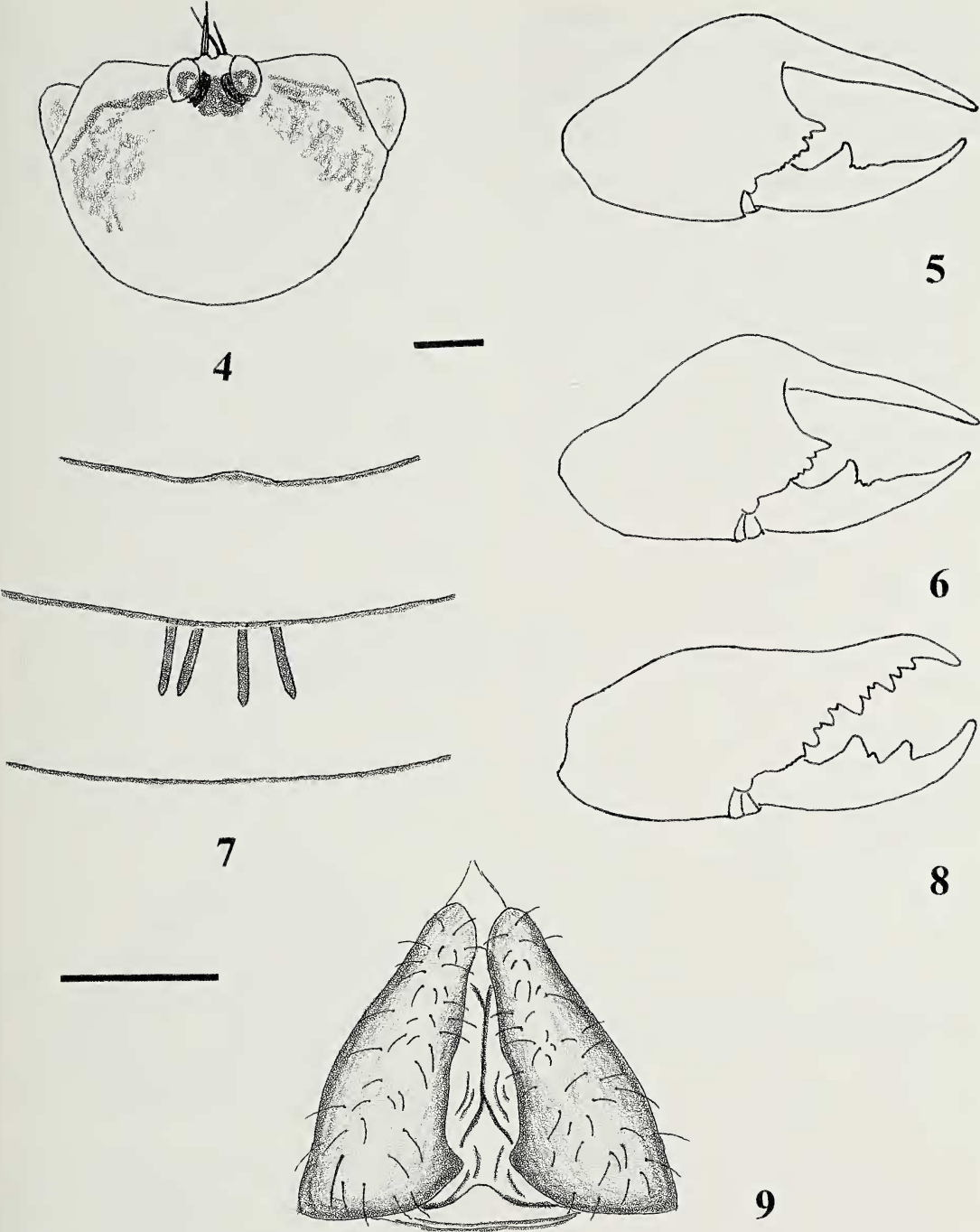
Using the methods of Muma (1951), Brookhart & Muma (1981, 1987) and Muma & Brookhart (1988) we measured the length of palpus, leg I, leg IV; length and width of chelicera and propeltidium; length and width

of fondal notch; and width of base of fixed finger. Fig. 2 indicates measurement areas. Abbreviations used to indicate various cheliceral structures are as follows: FF = fixed finger; MF = movable finger; PT = primary tooth; AT = anterior tooth; MT = medial tooth; IT = intermediate tooth; MST = mesal tooth. No satisfactory measurement of the depth of the notch could be found but depth could be inferred based on the amount of “crimping” or upturn of the male fixed finger. Those with a deeper notch demonstrated a more deeply crimped aspect when viewed ectally (see ectal view of *E. scaber*, Fig. 31). Female length; length of palpus, Leg I, Leg IV; length and width of chelicera, propeltidium and genital operculum were also made. All measurements are in millimeters.

The number, shape, and relative length of ctenidia to succeeding tergite was noted. Counts were made of palpal papillae. Color of palpus, legs I, II, III, IV and general overall color especially that of the propeltidium was recorded. The shape of the female genital operculum especially the medial margin was observed using some new terminology (see Fig. 3).

In addition to previously utilized characters, the shape of the anterior tooth of the male fixed finger, the absence or presence of a cleft anterior to the anterior tooth on both male and female cheliceral movable fingers, the presence and size of the mesal tooth, the position of the posterior intermediate tooth on the principal tooth of the male and female movable finger were analyzed. We investigated the Ectal Cheliceral Cluster Setae (ECCS) of Muma (1985) but found no useful parameters.

Ratios used previously by Muma (1951, 1970, 1989), Brookhart & Muma (1981, 1987), Muma & Brookhart (1988), and Brookhart & Cushing (2002) were computed. These ratios are as follows: A/CP = the sum of the lengths of palpus, leg I, and leg IV divided by the sum of length of chelicera and propeltidium indicating length of appendages in relation to body size. The larger the number, the longer legged is the species. FL/FW indicates whether the chelicera fondal notch is longer or wider. Longer is defined as the anterior to posterior axis and width is defined as the dorsal to ventral axis. FW/FFW diagnoses the size of fondal notch compared to



Figures 4-9.—*Eremobates icenoglei*, new species. 4. Dorsal view male propeltidium. 5. Ectal view male right chelicera. 6. Mesal view male right chelicera. 7. Ventral view male ctenidia. 8. Ectal view female right chelicera. 9. Ventral view female genital operculum. Scale lines = 1 mm.

the thickness of fixed finger. CW/FFW is used to indicate whether the fixed chelicera finger is thin or robust in relation to the size of the chelicera. GOL/GOW demonstrates the relative size of the female genital operculum in terms of length and width.

Because of limited and unequal sample size the Tukey-Kramer Analysis of Variance (ANOVA) was used to test differences in ratio means of each population as recommended by Sokal and Rohlf (1981). New parameters are given whenever possible for both males and females since Muma's measurements were sometimes based on a few specimens and from widely separated localities suggesting that more than one species might be included. We attempted to use specimens representative of a given species from a defined geographic province since it appeared that there was no sympatric association except in the Nevada Test Site area where *E. zinni* and *E. ascopulatus* appear to be sympatric.

Over 250 specimens were used in this study, many more than were available to other investigators. We describe the male of *E. scaber* and the females of *E. clarus*, *E. similis*, *E. actenidia* and *E. hodai*. Every species except *E. legalis* Harvey 2002 is now known from both sexes and a reduced and more specific geographic range for each implied.

The following institutions have loaned us types and specimens for observations: American Museum of Natural History (AMNH), Norm Platnick; Athabasca University (ABU), Robert Holmberg; Brigham Young University (BYU), Richard Bauman; California Academy of Science (CAS), Charles Griswold; Colorado State University (CSU), Boris Kondratieff; University of Colorado at Boulder (CU), Virginia Scott; Florida State Collection of Arthropods (FSCA), G.B. Edwards and Paul Skelly; University of New Mexico Museum of Southwestern Biology, Sandy Brantley; Utah State University (USU), Wilford Hansen; State of Idaho Dept. of Environmental Quality (ID), W.H. Clark; Spencer Museum, University of British Columbia, Vancouver (SMUBC); Royal British Columbia Museum, Victoria (RBCM); Royal Ontario Museum, Toronto (ROM); Washington State University James Entomological Collection (WSU), Richard Zack; Museum National d'Histoire Naturelle, Paris, France (MNHN), Christine Rollard.

SYSTEMATICS

Family Eremobatidae Kraepelin Genus *Eremobates* Banks 1900

Datames Simon 1879:113 (preoccupied).

Datames scaber Kraepelin 1899.

Eremobates Banks 1900:426 (new name for *Datames* Simon).

Eremoperna Roewer 1934:557 (in part).

Eremopus Roewer 1934:561 (in part).

Eremognatha Roewer 1934:566 (in part).

Eremocosta Roewer 1934:569 (in part).

Eremostata Roewer 1934:571 (in part).

Type species.—*Gluvia cinerascens* E.L. Koch 1842 (junior synonym of *Galeodes palipes* Say 1923). Muma (1951) described the genus *Eremobates* as small to medium sized Eremobatidae with a mesoventral groove that extends the entire length of the male fixed finger. The flagellum complex is composed of a dorsal row of simple tubular bristles that are sometimes striate and a ventral row of S-shaped, flattened, plumose bristles that form an arch over the basal third of the mesoventral groove. The apical, plumose bristle of the ventral row is straight and forms a parallel covering over the apical two-thirds of the mesoventral groove. The first post-spiracular abdominal sternite of males are with or without ctenidia. Genital operculum of female variable. This description did not change in later works (Muma 1962, 1970, 1989).

Eremobates scaber (Kraepelin 1901)

Figs. 31, 42, 47, 52

Datames scaber Kraepelin 1899:243, fig. 19f.

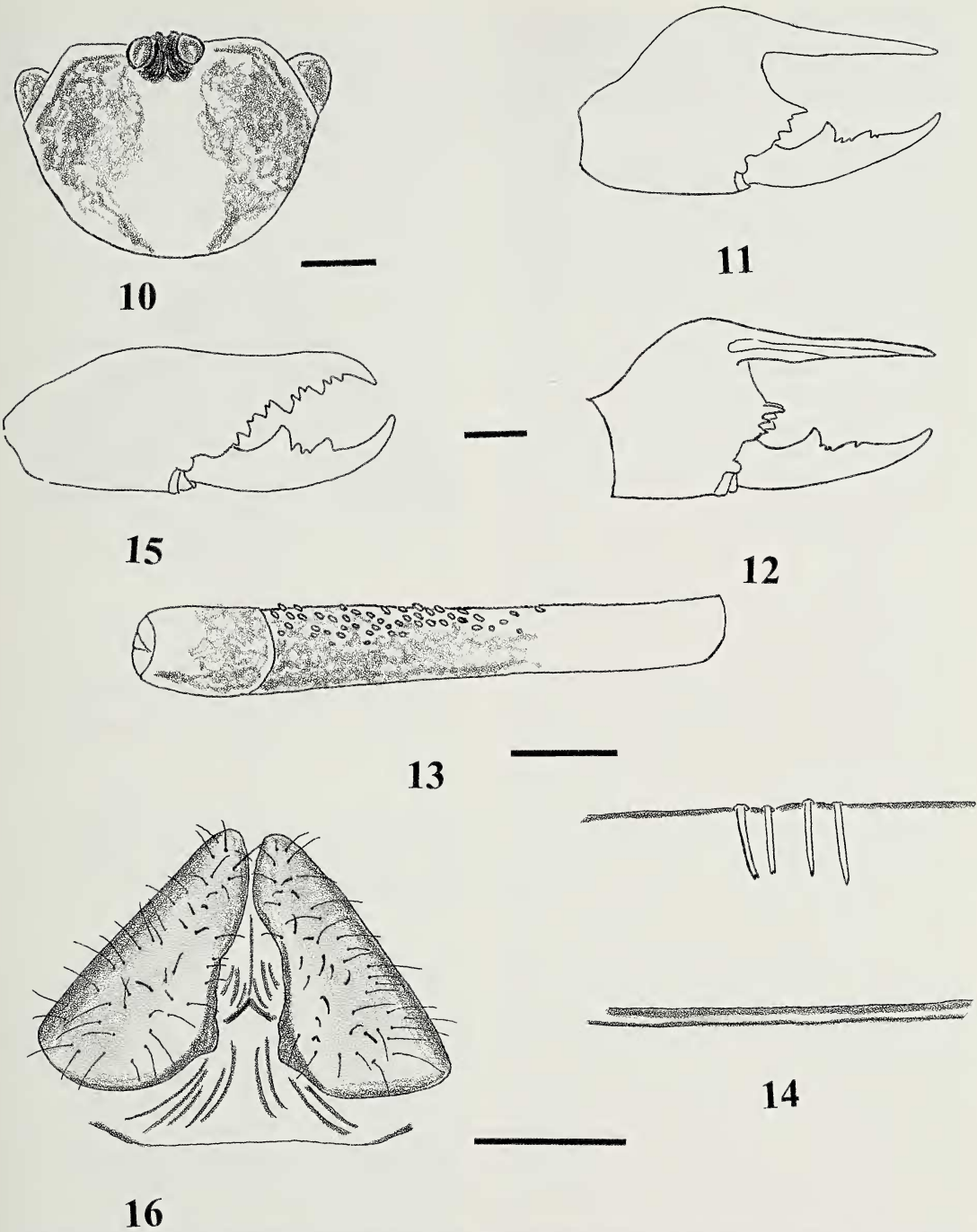
Eremobates scaber (Kraepelin 1899), Kraepelin 1901:124–125, fig. 91; Muma 1970:12, fig. 10; Muma 1989:8–9.

Eremostata scabra (Kraepelin), Roewer 1934:124.

Eremobates gladiolus Muma 1951:57–58, figs. 58–60; Muma 1970:11–12; Muma 1989:9. NEW SYNONYMY.

Type.—Female holotype of *Datames scaber* No. 9137, from "Washington Territory", US in the E. Simon collection, Paris, France (MNHN). Male holotype of *Eremobates gladiolus* from Maupin, Wasco County, Oregon, US (45°11'N, 121°04'W), 19 July 1934, J.M. Pearson, in AMNH. Female allotype from Starbuck, Columbia County, Washington, US (46°31'N, 118°07'W), 4 July 1938, C.S. Brenner, in AMNH.

Diagnosis.—Males: Most easily identified by the strongly upturned or "crimped" por-



Figures 10–16.—*Eremobates socal* new species. 10. Dorsal view male propeltidium. 11. Ectal view right male chelicera. 12. Mesal view right male chelicera. 13. Ventral view male right palpus. 14. Ventral view male ctenidia. 15. Ectal view right female chelicera. 16. Ventral view female genital operculum. Scale lines = 1 mm.

tion of the fixed finger of the male chelicera (Fig. 31). Two short, thin to flat ctenidia. It is separated from *E. clarus* by the shape of fixed finger and distinctive female genital operculum.

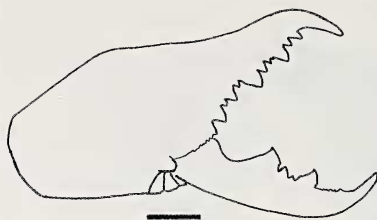
Description.—Males: Chelicera, propeltidium and appendages dusky yellow with the following markings: propeltidium blotched dusky purple except for a medial lighter dusky ovoid region (Fig. 47). Some specimens have light violet markings on distal third of leg IV and a chelicera with a dorsal and two lateral dusky purple stripes, abdomen dusky grey.

Chelicera as Muma (1951, fig. 58). FF severely crimped in ectal view (Fig. 31), MF with PT large, AT small, sharp, triangulate, 2 IT, 1st IT separated from PT, cleft under AT, mesal tooth absent, FT graded I, III, II, IV, FT III triangulate and large as FT I, FL/FW equal to or slightly wider, flattened apical plumose bristle occupies 75–80 percent of mesoventral groove, palpal metatarsus with a scopula of 33–80 rounded papillae; 2 short, thin to flat ctenidia (Fig. 42).

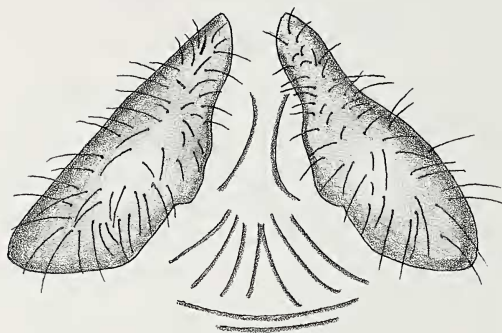
Male measurements(5): Hanford Site, Benton County, Washington, (WSU). Total length 18.5–25.0, chelicera length 5.00–6.72, chelicera width 2.64–3.04, propeltidium length 2.83–3.33, propeltidium width 3.96–4.38, palpus length 15.5–18.0, 1st leg length 13.0–16.0, 4th leg length 22.0–26.0. **Ratios:** A/CP 5.17–6.73, CL/CW 1.84–2.40, FL/FW 0.82–1.07, FW/FFW 1.28–1.55, CW/FFW 4.86–7.08, PL/PW 0.70–0.80.

Females: Coloration same as males, chelicera typical of species; FF with PT and MT large, a small AT, two IT between PT and MT, one small IT posterior to the AT; MF with large PT, pointed AT; two small IT, the proximal of which is larger; posterior IT separate from primary tooth; no cleft under AT of MF; MST indistinct or absent. Genital operculum as in fig. 10, p. 19, (Muma 1970) with short, thin arms, medial margin lobed, gently recurved wings ending in a curved posterior margin (Fig. 52). One specimen with 57 rounded papillae on metatarsus of palpus, the rest had none; two tiny hairlike ctenidia were present on one specimen, the rest had none.

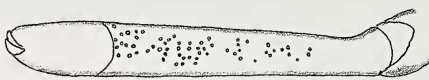
Female allotype: Total length 19.0, chelicera length 6.4, cheliceral width 3.1, propeltidium length 2.9, propeltidium width 4.16, palpus length 16.0, first leg length 11.0, fourth leg length 22.5. **Ratios:** A/CP 5.32, CL/CW



17



18



19

Figures 17–19.—*Eremobates hodai* Muma. 17. Ectal view female chelicera. 18. Ventral view female genital operculum. 19. Ventral view right male palpus. Scale lines = 1 mm.

2.06, PL/PW 7.00, GOL/GOW 0.72. **Female measurements** (3): Length 19.0–23.0, chelicera length 6.04–7.50, chelicera width 2.29–3.29, propeltidium length 2.58–3.30, propeltidium width 3.96–4.58, palpus length 14.0–17.0, first leg length 11.0–15.0, fourth leg length 18.0–25.0. **Ratios:** A/CP 4.86–5.26, CL/CW 2.28–2.95, PL/PW 0.65–0.73, GOL/GOW 0.50–0.67.

Remarks.—Muma (1951) described *E. scaber* using a sample population of both males and females from a geographic area extending from Washington state to the deserts of Arizona. He remarked as to the variability of the species and suggested that it might include two or more species. Unfortunately his drawings of the female genital operculum (1951, p. 53, fig. 53) were obviously of another species. After viewing Kraepelin's fe-

male type from Washington Territory, Muma (1970) described *E. scaber* based solely on the type and indicated that males were unknown. In the same publication (Muma 1970) used his 1951 description of *E. scaber* to establish the new species, *E. septentrionis* (Muma 1970).

Muma's (1951) description of *E. gladiolus* listed the male holotype from Maupin, Oregon, the female paratype from Starbucks, Washington, and paratypes from Umatilla, Oregon and Wishrum, Washington, all in the Columbia River Basin. Muma uses only a slight difference in the coloration on leg IV to differentiate the two species. After examination of material from Hanford Test Site in Washington state and Canadian samples from the Okanogan Valley, and the subsequent examination of the types of *E. scaber* and *E. gladiolus*, we have synonymized the two species under *E. scaber* based on the shape of the female genital operculum and the male fixed finger.

The collection sites indicate a range that encompasses the Columbian River Basin, and the Okanogan Valley in northern Washington, USA and the Okanogan Valley, southern British Columbia, Canada which are primarily high desert shrub communities (USEPA 1986).

Specimens examined.—Males: UNITED STATES: *Oregon*: Washington County, Maupin (45°10'N, 121°04'W), July 1934, J. M. Pierson (♂, AMNH); Umatilla County, Umatilla (45°55'N, 119°20'W), 24 June 1882, S. Henshaw (♀, AMNH). *Washington*: Benton County, Hanford Nuclear Site (46°32'N, 119°31'W), 23 July–8 August 1999, Rich Zack (8 ♂, 3 ♀, WSU); Whitman County, Wawsweiko Peak (46°32'N, 118°79'W), 27 July 1981, no collector data (♂, WSU). CANADA: *British Columbia*: Osoyoos, Haynes Ecological Reserve (49°07'N, 119°40'W), 19 June 1986, S.G. Cannings (2 ♂, Spencer Museum, University of British Columbia); 14 June–3 August 1987 (♂, ♀, ABU); Osoyoos, Mount Kobau, 10–33 July 1991, D. Blades & C. Maier (♂, Royal British Columbia Museum, Victoria); Penticton (49°10'N, 119°31'W), 1973, W. D. Charles (♂, ABU); 5 July 1973, M. Redivo (♂ ABU); 27 August 1972, Jose Matias (♂, ABU); Summerland (49°36'N, 119°40'W), 3 July 1928, T. B. Kurta (♀, Royal Ontario Museum, Toronto); August–November 1982, W. D. Charles (♂, ABU); Ker-

emeos (49°12'N, 119°50'W), 6 September 1960, Philip Desjardins (♀, Spencer Museum, University of British Columbia); Oliver (49°11'N, 119°33'W), J. Slack (♀, Spencer Museum, University of British Columbia).

Eremobates ctenidiellus Muma 1951

Figs. 32, 38, 48, 55

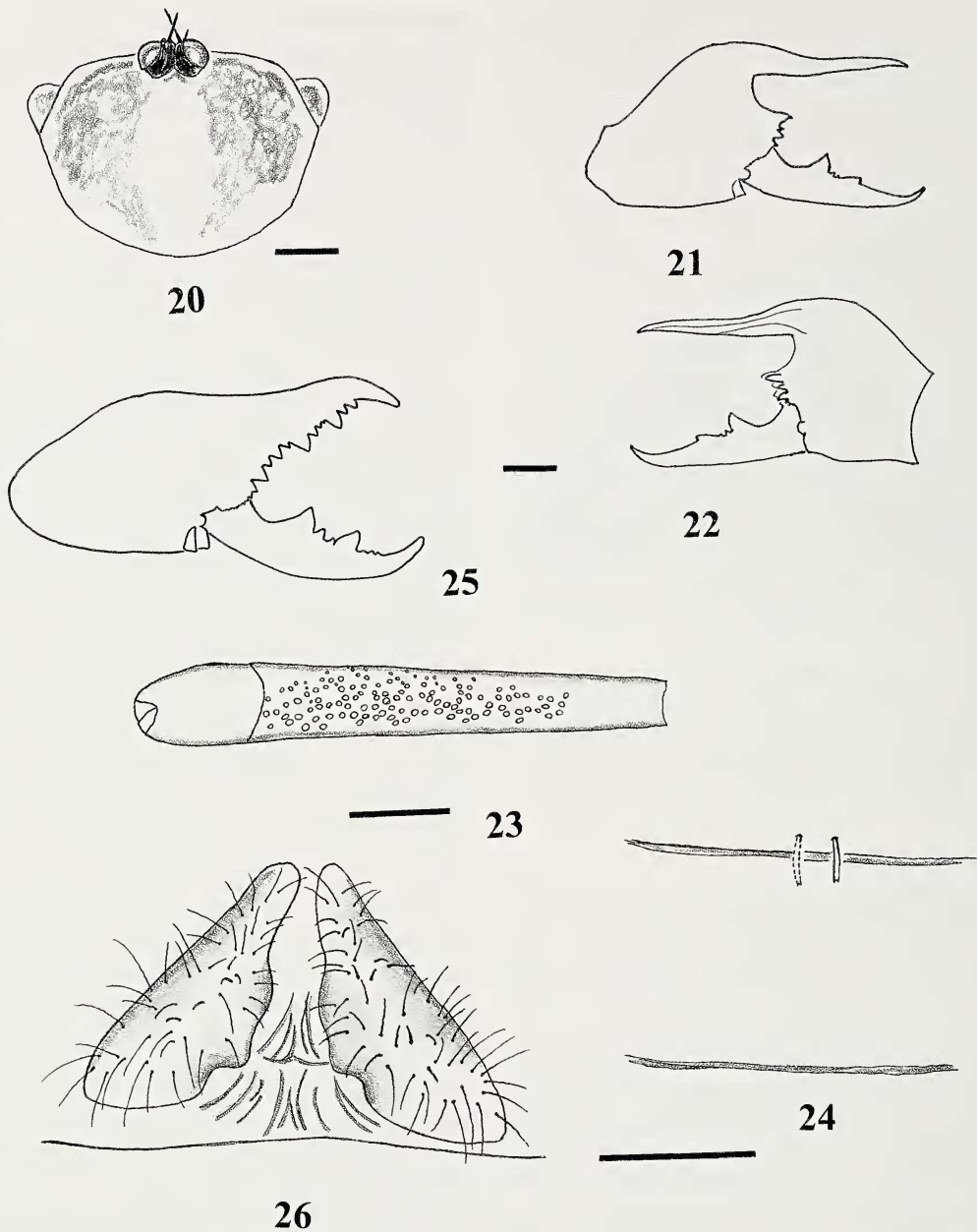
Eremobates ctenidiellus Muma 1951: figs. 58–60; Muma 1962:3; Muma 1963:1; Muma 1970:10; Muma & Allred 1971:165; Brookhart 1972:33; Muma 1987:20.

Type.—Male holotype and female allotype from 3.2 km west of Glenwood, Sevier County, Utah, US (38°45'N, 111°59'W) 30 June 1940, Gertsch & Hook in AMNH. Muma (1951) lists paratypes in U.S. National Museum, Museum of Comparative Anatomy, USU, Cornell University (Muma 1951) but there are no paratypes at USU (Wilford Hansen pers. comm.).

Diagnosis.—Pale species, with 0–2 very thin hairlike ctenidia. Posterior IT of male and female MF in the notch of PT, no cleft under AT. Female genital operculum distinctive with virtually no modification of the interior edge except for a heavily chitinated region which makes it appear as if there is a spot on the medial edge. Fondal notch length equal to width.

Description.—Males: Muma's (1951) description is accurate. Appendages pale yellow, propeltidium dusky, violet brown except for a medial pale yellow ovoid region (Fig. 48), abdomen dusky. Chelicera as in fig. 58, p.56, Muma (1951). A thin FF slightly crimped in ectal view, MF with large PT and smaller slightly crumpled AT, no cleft anterior to AT, IT in notch of PT. MST tiny to absent, fondal teeth typical (Fig. 32). Palpus with 50–100 rounded, white papillae on the metatarsal scopula, ctenidia 0–2 thin, hair-like setae (Fig. 38).

Male holotype: Total length 22.0, chelicera length 5.6, chelicera width 3.2, propeltidium length 3.0, propeltidium width 4.0, palpus 18.0, 1st leg 15.0, 4th leg 23.0. *Ratios*: A/CP 6.36, CL/CW 3.20, PL/PW 0.75, FL/FW 1.01, FW/FFW 1.25, CW/FFW 5.70. *Male measurements* (5): Total length 17.0–23.0, chelicera length 4.6–6.1, chelicera width 2.2–3.2, propeltidium length 2.4–3.2, propeltidium width 3.3–4.4, palpus length 15.0–18.5, first leg length 13.0–15.0, fourth leg length 17.5–



Figures 20–26.—*Eremobates corpink* new species. 20. Dorsal view male propeltidium. 21. Ectal view male right chelicera. 22. Mesal view male right chelicera. 23. Ventral view male right palpus. 24. Ventral view male ctenidia. 25. Ectal view female chelicera. 26. Ventral view female genital operculum. Scale lines = 1 mm.

25.0. *Ratios:* A/CP 6.15–7.23, CL/CW 1.64–2.34, PL/PW 0.58–0.80, FL/FW 0.80–1.00, FW/FFW 2.67–3.75, CW/FFW 5.50–7.00.

Females: Coloration the same as in the males. Chelicera typical of species; MF with posterior IT in notch of PT, no cleft under AT, MST indistinct to absent. Genital operculum

as in fig. 60, p. 56 Muma (1951) with short, broad arms, long medial margin with a dark chitinized area midway, very slightly undulate, wings short, posterior margin slightly curved (Fig. 55). No papillae on metatarsus of palpus; two tiny hairlike ctenidia were present on one specimen, the rest had none.

Female allotype: total length 19.0, chelicera length 4.6, chelicera width 1.8, propeltidium length 2.5, propeltidium width 3.6, palpus 13.0, first leg length 11.5, fourth leg length 21.5. *Ratios*: A/CP 6.60, GOL/GOW 0.75. *Female measurements (3)*: Total length 18.5–21.0, chelicera length 4.6–6.7, chelicera width 2.0–2.4, propeltidium length 2.1–3.0, propeltidium width 3.2–4.2, palpus length 11.5–14.0, first leg length 10.5–13.0, fourth leg length 20.5–22.0. *Ratios*: A/CP 5.05–6.70, CL/CW 2.30–2.79, PL/PW 0.58–0.71, GOL/GOW 0.72–0.82.

Remarks.—Measurements were made from specimens collected at various times in Colorado National Monument and adjacent areas. Four males but no females were found by Brookhart in pitfall traps during the summer of 1998. The range of collected specimens indicates an area within the central regions of the Colorado Plateau.

Specimens examined.—UNITED STATES: *Colorado*: Mesa County, Colorado National Monument (39°03'N, 108°41'W), 15 July 1962, C.J. McCoy (♂, CU); 21 June 1963, B. Vogel & C.J. McCoy (♂, CU); 29 June 1973, C.J. McCoy (♀, CU); 3 July 1973, C.J. McCoy (♀, CU); Grand Junction (39°03'N, 108°33'W), 26 May–26 August 1998, Jack & Irene Brookhart (4 ♂, DMNS), *Utah*: Grand County, 32 Km west of Glade Park, coordinates unknown, 18 June 1951, no collection data (♂, CU); Emery County, Castle Dale (39°12'N, 111°01'W), 26 June 1951, D.E. Beck (♀, BYU); 7 July 1975, D.M. Allred (♂, BYU); Sanpete County, Manti (39°16'N, 111°38'W), 21 June 1979, Ryan Olson (♀, USU); Sevier County, Richfield, (38°46'N, 112°05'W), 9 July 1963, G. F. Knowlton (♀, BYU).

Eremobates clarus Muma 1989

Figs. 33, 36, 45, 54

Eremobates clarus Muma 1989:10.

Type.—Male holotype at 2194 meters in pitfall trap, Saratoga Stratton Experimental Watershed, Carbon County, Wyoming, US (41°27'N, 106°48'W), 17–21 July 1973, collected by John Schmid, AMNH. One male paratype from same trap (AMNH).

Diagnosis.—Distinguished from closely related *E. scaber* by less crimped, more smoothly curved FF in ectal view, and the cleft under the AT of the MF. Female operculum has

broader anterior arms and less undulation of the medial margin of the genital operculum. It is distinguished from *E. ascopulatus* by its pale coloration, slightly different female genital operculum, and shape of ctenidia.

Description.—Males: Muma adequately described the male in 1989. Overall coloration very pale yellow, propeltidium dusky violet brown similar to *E. scaber* but with a larger median pale ovoid region, abdomen dusky, palpus and all legs pale yellow. Some specimens are dusker on propeltidium and appendages.

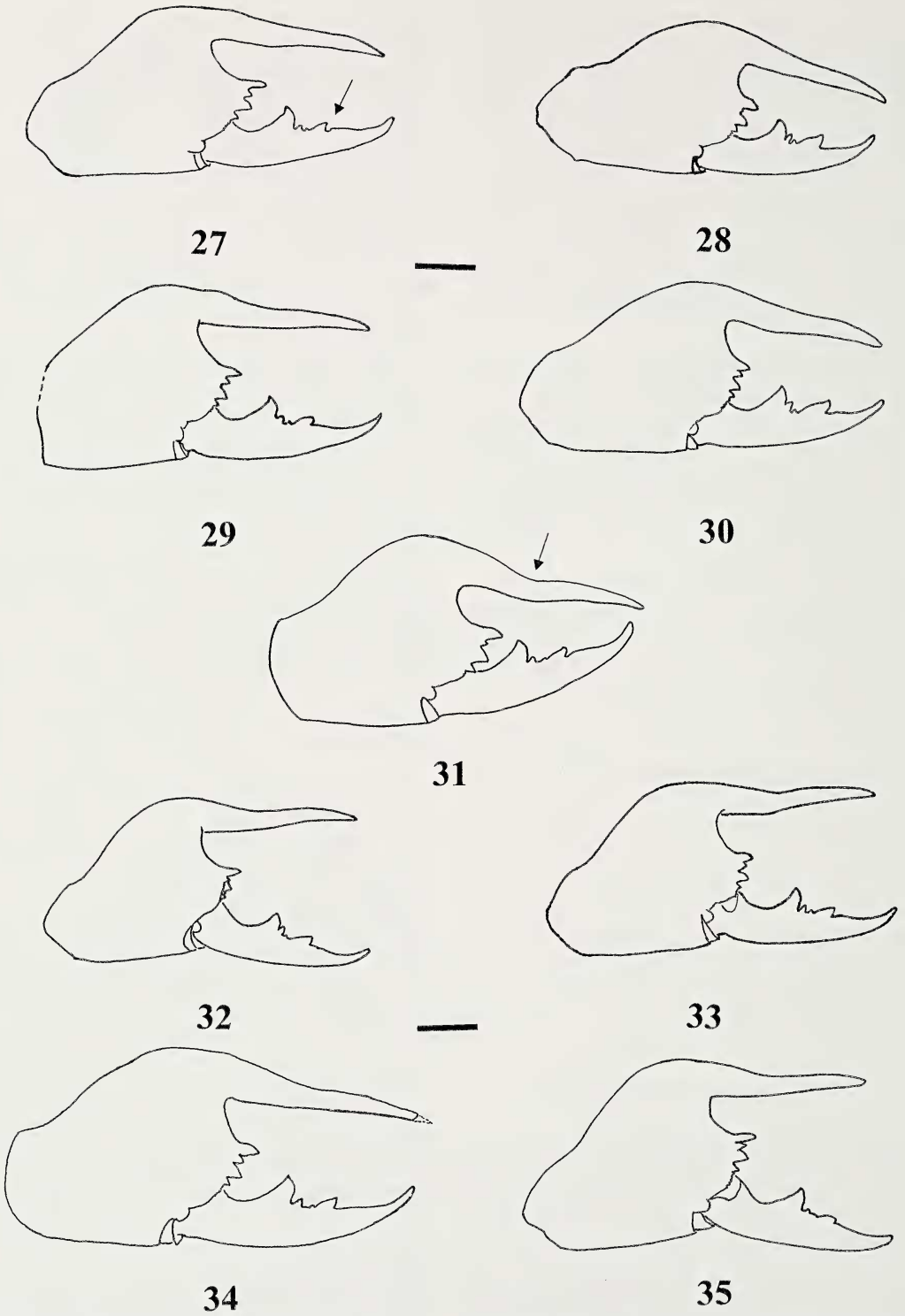
Thick, male FF gently curved to only slightly upturned in ectal view, no teeth, MF with posterior IT separate from PT, AT with anterior cleft, MST absent, FT graded I, III, II, IV, Fondal notch equal to or slightly wider (Fig. 33). Palpal papillae 33—80 +, two tiny, peg-like ctenidia (Fig. 36).

Male holotype: Total length 19.0, chelicera length 4.7, chelicera width 2.3, propeltidium length 2.3, propeltidium width 3.4, palpus length 16.0, first leg length 12.0, fourth leg length 20.0. *Ratios*: A/CP 6.86, PL/PW 0.76, CL/CW 2.04, FL/FW 0.72. *Male measurements(5)*: Length 18.0–22.0, chelicera length 4.6–6.6, chelicera width 2.2–3.2, propeltidium length 2.2–2.6, propeltidium width 3.4–3.6, palpus length 13.5–17.0, first leg length 11.0–12.5, fourth leg length 17.0–21.0. *Ratios*: A/CP 5.32–6.86, CL/CW 1.86–2.19, PL/PW 0.63–0.72, FL/FW 0.80–1.20, FW/FFW 2.80–3.75, CW/FFW 4.40–6.40.

Females: Coloration as in males, chelicera typical of group. Posterior IT of MF separate. Cleft under AT, MST tiny. Genital operculum with short, broad arms, medial margin undulate forming two small lobes, arms long, gently curved, posterior margin rounded (Fig. 54).

Female measurements(6): Length 18.0–24.0, chelicera length 4.8–6.4, chelicera width 2.20–2.65, propeltidium length 1.6–2.6, propeltidium width 3.0–3.6, palpus length 13.0–15.5, first leg length 9.5–11.2, fourth leg length 16.0–21.0. *Ratios*: A/CP 4.92–6.97, CL/CW 2.04–2.50, PL/PW 0.50–0.72, GOL/GOW 0.46–0.56.

Remarks.—*Eremobates clarus* was collected by Brookhart during the summer of 1998 from pitfall traps placed in both Piñon pine-Juniper and greasewood (*Sarcobatus* sp.) habitats in northwest Colorado near Dinosaur National Monument. It appears to occupy the area



Figures 27–35.—Ectal view male right chelicerae (arrow shows cleft under anterior tooth). 27. *E. zinni*. 28. *E. similis*. 29. *E. mormonus*. 30. *E. actenidia*. 31. *E. scaber* (arrow showing “crimp” in male fixed finger). 32. *E. ctenidiellus*. 33. *E. clarus*. 34. *E. hodai*. 35. *E. ascopulatus*. Scale lines = 1 mm.

encompassed by the Laramie Plateau. The female is described for the first time.

Specimens examined.—UNITED STATES: *Colorado*: Moffat County, Castle Park, Dinosaur National Monument (40°28'N, 108°53'W), 18–30 June 1948, Hugo Rodeck (4 ♂, CU); 4 July 1949, Hugo Rodeck (♂, ♀, CU); 3.2 Km W of Craig (40°30'N, 107°32'W), 26 May–16 June 1971, Jack & Irene Brookhart (2 ♂'s, ♀, CU); 35.4 Km W of Craig, 18 June 1993, no collector (♀, CU); 19.3 Km W of Craig, 1 May–26 July 1998, Jack & Irene Brookhart (3 ♂, DMNS). *Wyoming*: Carbon County, Saratoga Stratton Experimental Station (41°27'N, 106°48'W), Jon Schmid, (♂, DMNS).

Eremobates hodai Muma 1989

Figs. 17–19, 34, 40, 46

Eremobates hodai Muma 1989:13, fig. 14.

Type.—*Eremobates hodai* male holotype labeled College of Idaho with no other information. Deposited in FSCA.

Diagnosis.—Related to *E. scaber* and *E. clarus* from which it differs in coloration, shape of fondal notch, and female genital opercula. Although the holotype lacks palpal papillae and ctenidia other male specimens have papillae and ctenidia.

Description.—Males: Pale yellow coloration, palpus, legs pale, anterior region of propeltidium pale violet, eye tubercle dark. Chelicera pale with no stripes, typical dentition, FF crimped in ectal view, MF with posterior IT separate from PT, no cleft under AT (Fig. 34). Two short, pointed ctenidia (Fig. 40), 75–106 palpal papillae (Fig. 19).

Male holotype: Total length 21.0, chelicera length 6.5, chelicera width 3.3, propeltidium length 3.5, propeltidium width 4.0, palpus length 20.0, first leg length 17.5, fourth leg length 25.0. *Ratios:* A/CP 6.35, CL/CW 1.70, PL/PW 0.88, CL/CW 2.20, FL/FW 0.88, FW/FFW 1.14, CW/FFW 4.00. *Male measurements* (3): Total length 17.0–23.0, chelicera length 6.25–6.46, chelicera width 2.17–3.00, propeltidium length 2.71–3.42, propeltidium width 3.54–4.67, palpus length 15.0–19.0, first leg length 11.0–15.5, fourth leg length 19.0–22.0. *Ratios:* A/CP 5.07–5.77, CL/CW 2.15–2.98, PL/PW 0.73–0.76, CL/CW 2.15–2.98, FL/FW 0.95–1.00, FW/FFW 1.33–1.42, CW/FFW 4.73–5.17.

Females: Coloration as in males. Chelicera

typical, posterior IT separate from PT, no cleft under AT (Fig. 17). Genital opercula similar to *E. scaber* with long, broad arms, medial margin slightly curved inward, wings offset, long, posterior margin short ending in a point (Fig. 18). *Female measurements* (3): Total length 18.0–22.0, chelicera length 4.71–7.29, chelicera width 2.58–3.33, propeltidium length 2.83–3.33, propeltidium width 4.17–5.00, palpus length 13.0–15.0, first leg length 11.0–13.0, fourth leg length 18.0–21.0. *Ratios:* A/CP 4.61–5.83, CL/CW 1.66–2.00, PL/PW 0.66–0.70, GOL/GOW 0.82–0.86.

Remarks.—*Eremobates hodai* was found in the Snake River Plain region of the Columbia River Plateau (USEPA 1986). Allred & Muma (1971) identified *E. septentrionis*, now *E. ascopulatus* and *E. ctenidiellus* from this region but were in error. Although this species may later be synonymized with *E. clarus* or *E. scaber*, its small A/CP and its pale lemon coloration leads us to separate it at this time.

Specimens examined.—UNITED STATES: *Idaho*: Ada County, Eagle (43°41'N, 116°21'W), August 1987, W.H. & Mary Clark (2 ♀, ID); Butte County, 30 Km E of Arco, 6 June 1987, W.H. & Mary Clark (♂, ID); 41.8 Km SE of Howe, W.H. & Mary Clark (♀, ID); 35.4 Km SE of Howe, 2–16 July 1987, P. Blom, W.H. Clark (♂, ID). *Oregon*: Baker County, Sumpter (label says Idaho) (45°05'N, 113°44'W), 26 July 1995, W.H. & Mary Clark (♂, ♀, ID).

Eremobates ascopulatus Muma 1951

Figs. 35, 43, 49, 53

Eremobates ascopulatus Muma 1951:60, fig. 19.

Eremobates scaber (Kraepelin) *sensu* Muma 1951: 52–55, figs. 44–53 (not *E. scaber* Kraepelin).

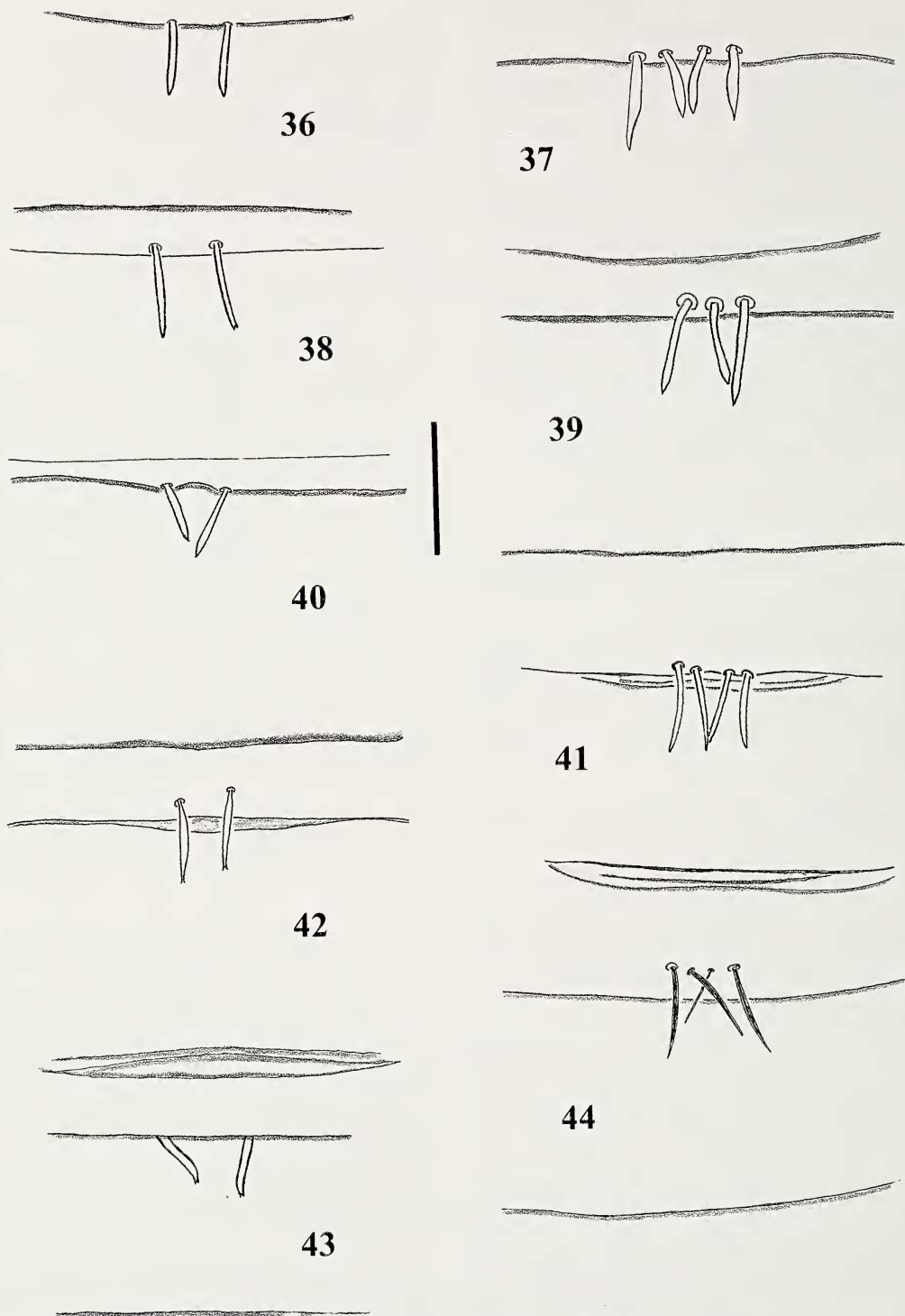
Eremobates septentrionis Muma 1970:12–14; Muma & Allred 1971:164; Brookhart 1972:33. NEW SYNONYMY.

Eremobates flavus Muma 1989:11–12, figs. 7–9. NEW SYNONYMY.

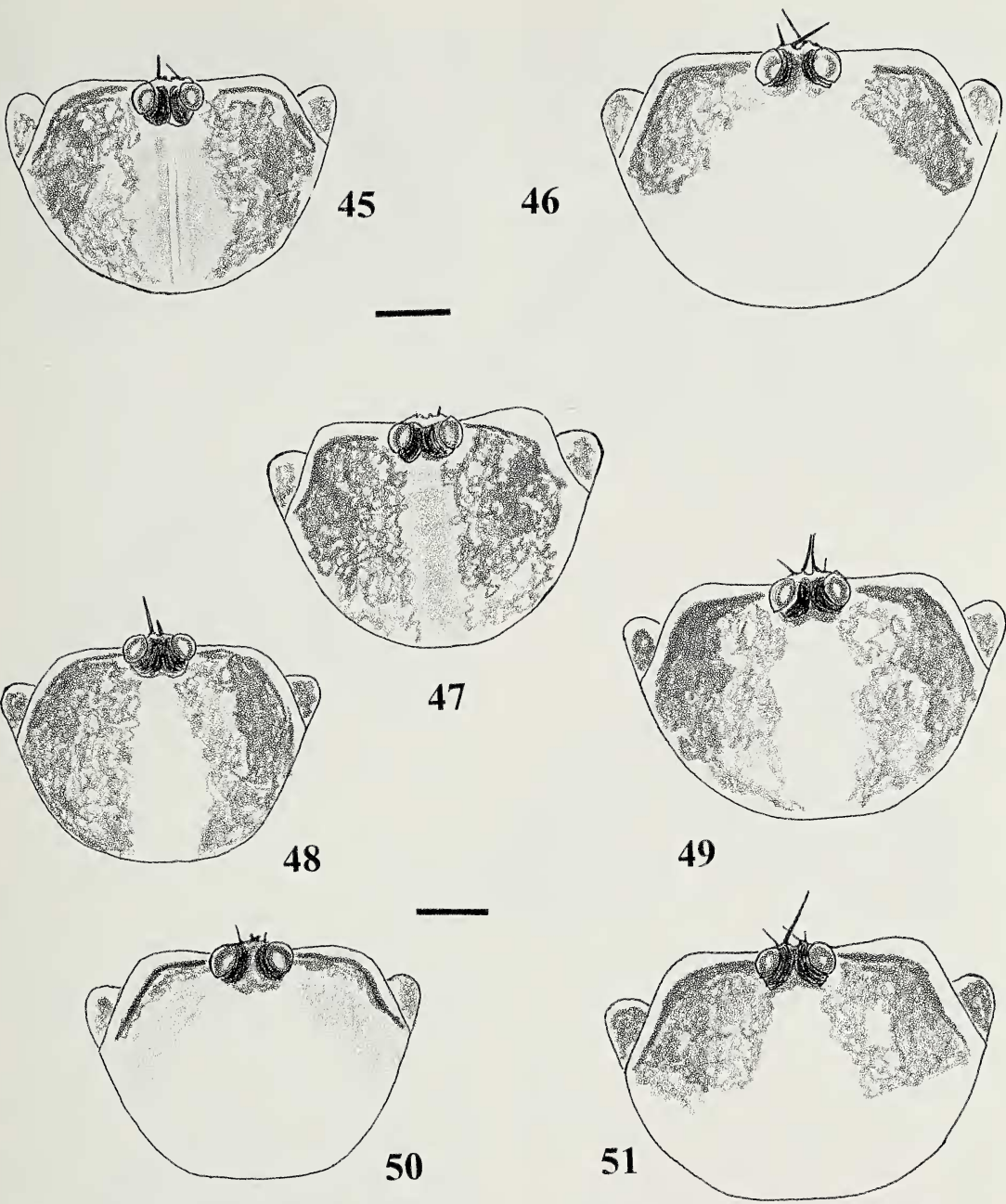
Eremobates consors Muma 1989:11, figs. 5–6. NEW SYNONYMY.

Type.—Male holotype of *E. septentrionis* from Richfield, Utah, Sevier County, 20 June 1930, W.J. Gertsch (AMNH).

Eremobates flavus: Male holotype collected in Reno, Washoe County, Nevada by W.F. Hendrick, 7 July 1972; female allotype collected in Jungo, Humboldt County, Nevada by L.L. Stütt (holotype and allotype in FSCA).



Figures 36-44.—Ventral view of male ctenidia. 36. *E. clarus*. 37. *E. mormonus*. 38. *E. ctenidiellus*. 39. *E. zinni*. 40. *E. hodai*. 41. *E. similes*. 42. *E. scaber*. 43. *E. ascopulatus*. 44. Female *E. similes*. Scale lines = 1 mm.



Figures 45–51.—Dorsal view male propeltidia. 45. *E. clarus*. 46. *E. hodai*. 47. *E. scaber*. 48. *E. ctenidiellus*. 49. *E. ascopulatus*. 50. *E. zinni*. 51. *E. mormonus*. Scale lines = 1 mm.

Eremobates consors: Female holotype from Minden, Douglas County, Nevada collected by D.A. Ball (Code #83H30-2 FSCA).

Diagnosis.—*Eremobates ascopulatus* appears to be related to *E. clarus*. It is distinguished by the shape of male chelicera, col-

oration of palpus and shape of female genital opercula.

Description.—Male: Overall coloration dusky, straw yellow, chelicera with two dusky purple patches dorsally and one laterally, propeltidium tinged dusky purple anteriorly and laterally creating a broad, dusky yellow, ovoid

area (Fig. 49), abdomen grey to dark grey, palpal tarsus and metatarsus darker than the other appendages. Occasionally specimens have legs that are dusky at the tibia-femur joint. Some northern California specimens are darker, particularly the propeltidium and palpus.

Male FF only slightly upturned in ectal view, posterior IT separate from PT, small, tri-angulate AT without a cleft, fondal notch L/W highly variable, MST medium (Fig. 35), 60–80 + palpal papillae on most specimens, two short peg-like ctenidia (Fig. 43).

Male holotype: Total length 21.0, chelicera length 5.76, chelicera width 2.73, propeltidium length 3.1, propeltidium width 3.8, palpus length 18.0, first leg length 15.0, fourth leg length 23.5. *Ratios*: A/CP 6.60, CL/CW 2.10, PL/PW 0.81, FL/FW 1.20, FW/FFW 1.38, CW/FFW 6.20. *Male measurements (5)*: Total length 19.5–23.0, chelicera length 5.25–6.13, chelicera width 2.45–2.98, propeltidium length 2.80–2.98, propeltidium width 3.85–4.20, palpus length 16.0–19.5, first leg length 14.5–16.5, fourth leg length 20.0–23.5. *Ratios*: A/CP 6.27–6.62, CL/CW 1.82–2.19, PL/PW 0.68–0.73, FL/FW 0.74–1.22, FW/FFW 1.25–1.54, CW/FFW 4.86–7.08.

Females: Coloration as in males. Chelicera typical of scaber group. MF with posterior IT in the notch of PT, no cleft anterior to AT. Genital opercula similar to *E. ctenidiellus* and *E. geniculatus* with long broad arms, slightly undulate medial margin, short wings, curved posterior margin (Fig. 53). *Female measurements (4)*: Total length 18.5–27.0, chelicera length 5.0–7.6, chelicera width 2.4–3.2, propeltidium length 2.4–3.2, propeltidium width 3.8–5.4, palpus 15.0–19.0, first leg length 10.0–14.5, fourth leg length 20.0–25.0. *Ratios*: A/CP 4.96–5.90, CL/CW 2.08–2.73, PL/PW 0.55–0.74, GOL/GOW 0.42–0.80.

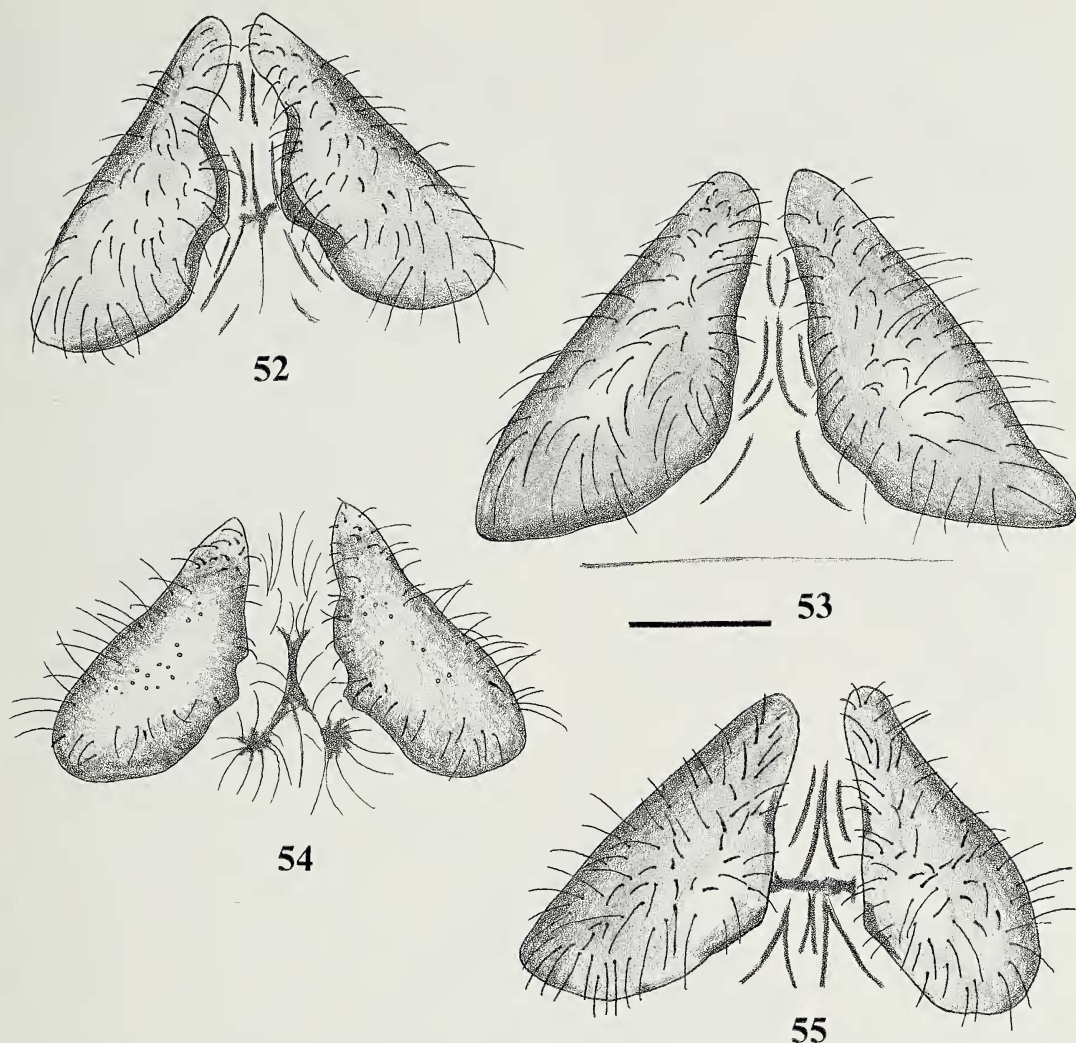
Remarks.—Muma (1951) misidentified *E. septentrionis* as *E. scaber* but after examining the holotype of the latter in Europe erected *E. septentrionis* using his 1951 description of *E. scaber* (1970). He deviated from the original description in describing the palpal color as dusky purple. We here synonymize *E. septentrionis* with *E. ascopulatus* based on examination of both types which differ in only the absence of palpal papillae in *E. ascopulatus*. In this study we have found that in large samples of papillate species there is an occasional

specimen without papillae. Our ongoing research seems to indicate that papillae may arise sequentially after the penultimate molt. *Eremobates ascopulatus* is known from only two male specimens both of which were found in the same geographic area as *E. septentrionis*. Because the description of *E. septentrionis* was based on specimens from many disparate parts of the western United States we have redescribed *E. ascopulatus* based on the holotype and reinforced by sample specimens.

Muma (1989) remarked as to the similarity between *E. septentrionis* and *E. flavus* and suggested that they may be the same species. We have found this to be the case. Muma's (1989) holotype of *E. flavus* from Reno, Nevada had longer, thinner ctenidia but other specimens from this area and nearby north-eastern California had ctenidia and female genital opercula as in *E. septentrionis*. Some of the northern California specimens were darker in overall color suggesting perhaps a sibling species but more specimens are needed for examination. *Eremobates consors* is known from only one female and erected based on the shape of the female genital operculum. Examination of the holotype indicates that the operculum was desiccated and is in reality *E. ascopulatus*.

Eremobates ascopulatus has a range that encompasses the Bonneville Basin and Lahontan Basin (see Trimble 1989) of northern Utah, Nevada, and northeastern California. It was also found at the Nevada Test Site (Muma 1963) where it is sympatric with *E. zinni*. Hall (1946) remarked as to the "intimate ecological connections" between the Lahontan basin and the Mojave Desert region of southern Nevada. These areas have the typical Great Basin desert shrub habitat. It appears to be related to *E. clarus* and *E. ctenidiellus*.

Specimens examined.—UNITED STATES: *California*: Placer County, Lake Tahoe (39°10'N, 120°08'W), no date, Hubbard & Swartz, (♂, FSCA); 11 July 1952, W.J. Gertsch (♀, AMNH); Plumas County, Lake Almanor (40°13'N, 121°10'W), 7 July 1952, W. J. Gertsch (♂, AMNH); 6.4 Km W of Quincy (39°56'N, 120°56'W), 21 June 1949, J. W. MacSwain (3 ♂ AMNH); Shasta County, Castella (41°08'N, 122°19'W), 26 July 1935, W. J. Gertsch (♀, AMNH). *Nevada*: Elko County, 14.5 Km S of Contact, M.H. Muma (♂, FSCA); Pershing County, Lovelock (40°10'N,



Figures 52–55.—Ventral view female genital opercula. 52. *E. scaber*. 53. *E. ascopulatus*. 54. *E. clarus*. 55. *E. ctenidiellus*. Scale line = 1 mm.

118°28'W), 22 June 1972, A.G. Rose (♀, FSCA); Washoe County, Reno (39°31'N, 119°48'W), 15 August 1989, P. C. Martenelli (2 ♂, ♀, FSCA). *Utah*: Box Elder County, Lucin (41°20'N, 113°54'W), 19 June 1952, D.E. Beck (2 ♂, BYU); Cache County, Logan (41°44'N, 111°50'W), 4 July 1949, Steve Dewey (♂, USU); 10 July 1995, D. Rasmussen (♂, USU); Davis County, Hill Air Force Base (The county designation is probably incorrect as Hill Air Force Base Recreation Area is located in Weber County, not Davis County.), 17 July 1991, Mike Peterson (♂, BYU); Salt Lake County, Sandy (40°35'N, 111°53'W), 24 June 1985, Teresa Tipton (♂,

USU); Utah County, Alpine (40°27'N, 111°46'W), 24 June 1997, A.L. Huillet (♂, BYU); Environs, no coordinates, 14 June 1972, Troy Cooper (♀, USU); Orem (40°17'N, 111°41'W), 20 June 1988, R. Williams (♀, BYU); 7 July 1993, Lisa Trotter (♂, BYU); Provo (40°14'N, 111°39'W), 1 September 1993, D.O. White (♀, BYU); Santaquin (39°58'N, 111°47'W), 18 July 1987, J. Jarvis (♀, USU); Spanish Fork (40°06'N, 111°39'W), 8 July 1979, D. C. Holt (♀, USU); Tooele County (says Uintah County on label), Vernon (40°05'N, 112°25'W), 7 August 1964, K. Bendixs (♀, USU); Weber County, Hill Air Force Base (41°13'N, 111°50'W), 27 July 1995, Larry Sanders (♂, BYU).

Eremobates icenoglei new species

Figs. 4–9

Type.—Male holotype collected by W. Icenogle in wet pit-fall trap, 29 August 1996, Winchester (33°42'N, 117°05'W), Riverside County, California; female allotype collected by W. Icenogle 22 Aug 1966 in wet pit-fall trap, Riverside County, California, 5 male paratypes, 5 female paratypes collected by W. Icenogle, Winchester, California, Riverside County in wet pit-fall traps 29 August 1967–23 August 1996. All types deposited in DMNS.

Etymology.—Named for the collector Wendell Icenogle of Winchester, California.

Diagnosis.—*Eremobates icenoglei* new species appears most closely related to *E. zinni* but is separated from it and others of the scaber group by absence of AT on male MF, a fond that is noticeably longer than wide, and a thickened FF. The female genital operculum is distinctive (Fig. 9).

Description.—Males: Coloration overall dark to dusky yellow, abdominal tergites dusky, appendages dusky yellow with palpal metatarsus and the tibia-femora joint area dusky violet-brown, propeltidium dusky purple on anterior edge and top lateral one third (Fig. 4).

Fixed finger of chelicera with little or no crimping, fondal notch longer than wide; width of FF 80% the width of FN; MF with large primary tooth, and a ridge that is slightly elevated anteriorly instead of intermediate and anterior teeth, MST intermediate in size (Fig. 5–6). Four stiletto shaped ctenidia on first post-spiracular sternite extending approximately half the length of the sternite (Fig. 7); no palpal papillae.

Male holotype: Total length 19.0, chelicera length 4.8, chelicera width 2.2, propeltidium length 2.6, propeltidium width 3.5, palpus length 16.0, first leg length 16.0, fourth leg length 23.0. *Ratios:* A/CP 6.82, CL/CW 2.20, FL/FW 1.40, WFF/FW 1.20, CW/WFF 4.23. **Male paratypes (5):** Total length 18.0–24.0, chelicera length 5.50–6.92, chelicera width 4.4–6.4, propeltidium length 2.32–3.20, propeltidium width 3.2–4.0, palpus length 14.0–17.0, first leg length 10.0–14.0, fourth leg length 17.0–24.0. *Ratios:* A/CP 5.52–6.80, CL/CW 1.73–2.20, FL/FW 1.17–1.44, FW/FFW 2.29–3.75, CW/WFF 4.23–5.75.

Female: Coloration the same as male. Chelicera typical of species; MF with posterior IT separate from PT, MST indistinct to absent (Fig. 8), no papillae on metatarsus of palpus; 2–3 tiny hairlike ctenidia were present on two specimens, the rest had none. Genital operculum with longer, broad arms, a long, slightly recurved medial surface ending in a point, wing short to absent, and posterior edge truncated (Fig. 9). **Female (allotype):** Total length 19.0, chelicera length 6.2, chelicera width 2.8, propeltidium length 2.0, propeltidium width 3.6, palpus length 12.0, first leg length 9.0, fourth leg length 17.5. *Ratios:* A/CP 4.70, CL/CW 2.20, PL/PW 0.55, GOL/GOW 0.82. **Female paratypes (5):** Total length 17.0–26.0, chelicera length 4.8–7.6, chelicera width 1.8–3.4, propeltidium length 2.0–3.0, propeltidium width 3.5–5.0, palpus length 12.0–16.0, first leg length 9.0–13.0, fourth leg length 16.0–22.0. *Ratios:* A/CP 4.70–5.66, CL/CW 2.20–2.67, PL/PW 0.48–0.63, GOL/GOW 0.74–0.82.

Remarks.—*Eremobates icenoglei* appears to be restricted to the Coastal Chaparral habitat. It was found by Wendell Icenogle in buildings and in pitfall traps.

Specimens examined.—UNITED STATES: *California:* Riverside County, Winchester (33°42'N, 117°05'W), 29 August 1967 (♂, 3 ♀), 16 September 1967 (2 ♀); 24 September 1968 (♀), 11 August 1973 (3 ♂), 3 September 1973 (3 ♀), 4 September 1973 (♀), 8 August 1981 (4 ♂), 17 August 1987 (3 ♂), 16 August 1988 (2 ♂), 1 August 1996 (2 ♂), 23 August 1996 (♂). All collected by Wendell Icenogle. Types and paratypes in DMNH.

Eremobates mormonus (Roewer 1934)

Figs. 29, 37, 51, 57

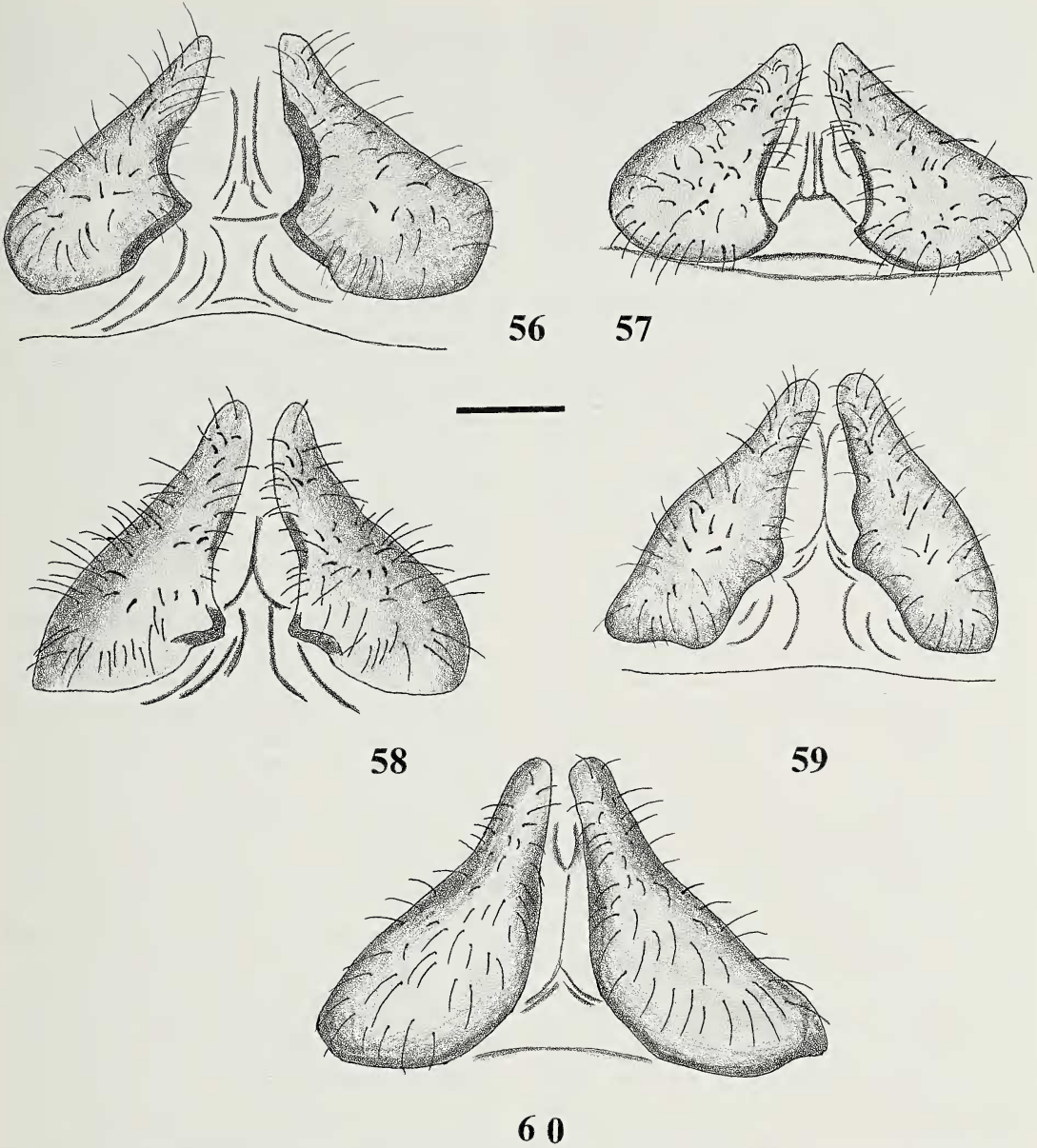
Eremoperna mormona Roewer 1934:561, figs. 323e, 324f.

Eremoperna mormonus (Roewer); Muma 1962:1; Muma 1970:12, fig. 9; Brookhart 1972:32.

Eremobates geniculatus (Simon) *sensu* Muma 1951:55–57 (misidentification).

Eremobates mimbrenus Muma 1989:12–13, figs. 10–13. NEW SYNONYMY.

Type.—Female holotype of *Eremoperna mormona* from Utah, SMF/RII/3446. No specific locality or collector indicated. Male holotype of *E. mimbrenus* from Signal Peak (32°55'N, 108°10'W), Grant County, New Mexico, 17 June 1976 and female allotype



Figures 56–60.—Ventral view female genital opercula. 56. *E. similis*. 57. *E. mormonus*. 58. *E. zinni*. 59. *E. actenidia*. 60. *E. legalis*. Scale lines = 1 mm.

from same locality collected on 1 July 1976. Both collected by Martin Muma (FSCA).

Diagnosis.—This species appears closely related to *E. similis* Muma but can be distinguished from it by its darker color, shape of fondal notch, presence of papillae, and thickness and length of ctenidia.

Description.—*Males*: Coloration dusky straw yellow over all, propeltidium dusky purple anteriorly and on the lateral one third (Fig.

51), tergites with broad violet brown stripe, abdomen grey, palpal tarsus and metatarsus dusky amber, legs dusky amber on femur-tibia joint. FF regularly curved; MF with large PT and AT, no cleft under AT, posterior IT in the notch of PT, MST tiny to absent. Fondal notch wider than long (Fig. 29); ctenidia 4 flat, sword like, extending slightly more than half the length of succeeding sternite (Fig. 37); 80+ papillae on palpal scopula. Apical plumose

bristle covers most of mesal groove. *Male measurements* (5): Total length 15.0–23.0, palpus length 10.0–22.0, first leg length 9.0–14.5, fourth leg length 14.5–23.0, chelicera length 3.5–5.4, chelicera width 1.6–2.6, propeltidium length 1.6–2.8, propeltidium width 2.00–3.85. *Ratios*: A/CP 6.08–7.59, CL/CW 1.94–2.20, PL/PW 0.70–0.80, FL/FW 0.50–0.67, FW/FFW 1.25–1.88, CW/FFW 4.60–6.20.

Females: Coloration same as males. Chelicera typical of species; MF with posterior IT in the notch of PT, no cleft under AT. MST indistinct to absent. Genital operculum similar to *E. zinni* and *E. socal*, new species as in fig. 68, pg. 59, Muma 1951 with short arms, medial surface gently curved ending in a point as in *E. zinni* and *E. similis*, short curved wing (Fig. 57). No papillae on metatarsus of palpus; seven tiny hairlike ctenidia were present on one specimen.

Female allotype: Total length 19.0, chelicera length 5.1, chelicera width 2.2, propeltidium length 2.3, propeltidium width 3.9, palpus length 12.5, first leg length 11.0, fourth leg length 18.5. *Ratios*: A/CP 5.75, CL/CW 2.31, PL/PW 5.90, GOL/GOW 0.54. *Female measurements* (3): Total length 18.5–21.0, chelicera length 4.40–5.02, chelicera width 2.0–2.1, propeltidium length 2.1–3.0, propeltidium width 3.4–3.6, palpus length 11.5–12.0, first leg length 10.5–12.0, fourth leg length 18.0–22.0. *Ratios*: A/CP 5.34–6.16, CL/CW 2.20–2.40, PL/PW 0.58–0.94, GOL/GOW 0.54–0.63.

Remarks.—This species was erroneously described as *E. geniculatus* by Muma 1951, but after examining the holotype in Paris he identified it as Roewer's species from Utah. Muma (pers. comm.) stated that the "type" of *E. mormonus* in the collection of MNHN is not Koch's type but may be a lectotype set up by Roewer and therefore invalid. No other locality data were given but it must have been somewhere in southwest Utah based on the presence of other species in that area. We found *E. mormonus* in northern Arizona around the Grand Canyon, SW Colorado and western New Mexico on mesas with sage, piñon pine-juniper and alpine meadows. The Arizona specimens are darker in overall coloration. We here synonymize *E. mimbrenus* with *E. mormonus*. *Eremobates mimbrenus* was described by Muma (1989), and the de-

scription that Muma gave is correct except that in his drawing of the right male chelicera, the IT is shown on the PT yet on the type specimen itself, the IT is separate (Muma 1989, fig. 12). In the same vial is a male and female, collected by Muma that appear to be *E. mormonus* as well as two other vials from the area with two males and a female which also key out to *E. mormonus*. Muma's (1989) description of the female allotype of *E. mimbrenus* was based on a female with three intermediate teeth on the movable finger collected in a pitfall trap in SW New Mexico. A female in the same vial does not have this character and could be recognized as *E. mormonus* based on genital opercula and chelicera structure. The male in the same vial is also recognized as *E. mormonus*. Until more specimens are collected from this area we have synonymized *E. mormonus* and *E. mimbrenus*.

Specimens examined.—UNITED STATES: *Arizona*: Coconino County, North rim of Grand Canyon (36°12'N, 112°03'W), 13 July 1934, Rockefeller, (2 ♀, AMNH); 18 July 1934, Lutz (♂, ♀, AMNH); 13 June 1934, Wilton Ivie (♂, AMNH); Flagstaff (35°11'N, 111°39'W), 22 July 1949, Billy Hughes (♀, AMNH); Kaibob Forest (35°50'N, 112°05'W), 14 June 1934, Ivie & Rasmussen (♂, AMNH). *Colorado*: Montezuma County, Chimney Rock (37°04'N, 108°43'W), 31 July 1973, B. Vogel (2 ♂'s, CU); McFee Reservoir (misspelling of McPhee Reservoir) (37°34'N, 108°34'W), 28 August 1997, B. Jacobi (2 ♂, 2 ♀, CSU); Miller Reservoir (37°37'N, 108°27'W), 28 August 1997, no collector (♂, CSU); Mesa Verde National Monument (37°14'N, 108°28'W), 23 July 1941, no collector (2 ♂, ♀, CU). *New Mexico*: Grant County, Signal Peak, Gila National Forest (32°55'N, 108°10'W), 6 July 1976, 1 July 1976), Martin Muma (2 ♂, ♀, FSCA).

Eremobates similis Muma 1951

Figs. 28, 41, 56

Eremobates similis Muma 1951:figs. 70–71; Muma 1962:4; Muma 1970:14; Muma 1989:9.

Type.—Male holotype, Elk Ridge, Utah County, Utah (40°00'N, 111°40'W), 13 June 1936, Douglas Henriques, originally deposited at University of Utah but now at AMNH.

Diagnosis.—Lighter coloration with a more violet tinge than the closely related *E. mor-*

monus with 4–6 short, thin, needle like ctenidia extending less than half the length of succeeding sternite, no palpal papillae.

Description.—*Males*: Appendages and propeltidium straw yellow with violet brown markings. Propeltidium lightly blotched violet brown on anterior and lateral margins, palpus and legs violet brown on femur, tibia, metatarsus, tarsus, abdominal tergites yellow grey. FF regularly curved in ectal view with no teeth; MF with posterior IT situated in the notch; AT triangulate with no cleft; MST tiny to absent. Fond significantly wider than long (Fig. 28); 4–6 thin, needle like ctenidia on first post spiracular sternite extending less than half the length of the sternite (Fig. 41). No papillae on palpal scopula. Both male and female descriptions are made from specimens collected in wet pit fall traps in Costillo County, Colorado in the summer of 1997 by J.O. and I.P. Brookhart. They were the most common solifugid found in the San Luis Valley of Colorado. They were referred to as *E. mormonus* by Brookhart (1972).

Male holotype: Total length 22.0, chelicera length 5.2, chelicera width 2.6, propeltidium length 2.5, propeltidium width 3.9, palpus length 17.0, first leg length 14.0, fourth leg length 22.0. *Ratios*: A/CP 6.88, CL/CW 2.00, PL/PW 0.64, FL/FW 0.50, FW/FFW 1.66. *Male measurements (6) (from San Luis Valley, Colorado)*: Total length 15.5–17.0, chelicera length 4.2–4.8, chelicera width 1.8–2.0, propeltidium length 2.0–2.2, propeltidium width 2.8–3.2, palpus 12.0–18.0, first leg length 11.0–16.5, fourth leg length 17.0–20.0. *Ratios*: A/CP 6.52–7.69, CL/CW 2.22–2.44, PL/PW 0.63–0.71, FL/FW 0.62–0.71, FW/FFW 3.50–4.33, CW/FFW 5.50–6.50.

Females: Coloration as in males, chelicera typical of species; MF with posterior IT in the notch of PT; MST indistinct to absent. Genital operculum with short, thin arms, interior lateral surface curved ending in a point as in *E. zinni* and *E. mormonus*, long recurved wings, rounded posterior margin (Fig. 56). No papillae on metatarsus of palpus; 2–5 tiny hairlike ctenidia were present on most specimens (Fig. 44).

Female measurements (6): Total length 16.5–22.0, chelicera length 4.20–5.52, chelicera width 1.8–2.4, propeltidium length 2.0–2.6, propeltidium width 3.0–4.0, palpus length 10.0–15.0, first leg length 8.0–11.5, fourth leg

length 14.0–21.0. *Ratios*: A/CP 5.30–5.76, CL/CW 2.33–2.88, PL/PW 0.62–0.81, GOL/GOW 0.58–0.71.

Remarks.—*Eremobates similis* was described from a specimen with a locality label from Salt Lake City, Utah. Although the type locality for *E. similis* is listed as Salt Lake City, Utah we have collected this species only in an area that can be roughly called the northern Rio Grande Valley at three sites, San Luis Valley, Colorado, Sevilleta LTER, Socorro County, New Mexico, and Bandelier National Monument, Sandoval County, New Mexico. Examination of the type fits Muma's description but we were unable to determine if there was an error in labeling the type locality. None of the specimens from Utah that we used in the scaber study could be identified as *E. similis*. Females of this species have not been previously described.

Each of the above populations occurred in high desert shrub habitat and varied somewhat in color. The male population of Bandelier National Monument had a statistically significant variation in A/CP ratio indicating the possibility of sibling species. San Luis Valley (2303 m) specimens were collected in Rabbit Bush, snake weed, greasewood habitats. Bandelier National Monument specimens from Piñon-Juniper and Ponderosa Pine habitat and Sevilleta LTER from Piñon-Juniper habitat but not from grassland and creosote bush (Brookhart & Brantley 2000).

Specimens examined.—UNITED STATES: *Colorado*: Costillo & Saguache Counties, San Luis Valley, 8 June–8 August 1997, Jack & Irene Brookhart in wet pitfalls (22 ♂, 19 ♀); *New Mexico*: Socorro County, Sevilleta National Wildlife Refuge (34°03'N, 106°23'W), 1989–1994 in wet pitfalls (7 ♂, 18 ♀); Sandoval County, Bandelier National Monument (35°47'N, 106°18'W), 1998–2000 in wet pitfall traps (22 ♂, 19 ♀). Deposited at DMNS and University of New Mexico.

Eremobates actenidia Muma 1989

Figs. 30, 59

Eremobates actenidia Muma 1989: 9–10, figs. 1, 2.

Type.—Male holotype from Gouldings Trading Post, Monument Valley, San Juan County, Utah, USA (37°06'N, 110°11'W), 2 June 1953, R.E. Ryckman, R.D. Lee, C.T. Ames, C.C. Lindt, C.T. Christianson. Deposited AMNH.

Diagnosis.—This specimen may be separated from all but *E. ctenidiellus* by its lack of ctenidia on the first post stigmatal segment. *Eremobates ctenidiellus* generally lacks ctenidia but can easily be distinguished by its pale coloration as opposed to the dark coloration of *E. actenidia* and the shape of the fondal notch, which is significantly longer than wide. It has a high A/CP ratio indicating longer appendages and a statistically thinner male fixed finger in relation to the fondal notch.

Description.—*Males*: Appendage and propeltidium coloration dusky yellow to brownish yellow, propeltidium tinged brownish violet on anterior and lateral margins, palpus tinged brownish violet on tarsus and metatarsus, legs dusky yellow. Cheliceral FF regularly curved, MF with small triangulate AT, no cleft, small IT with the posterior separate from the PT (Fig. 32), no ctenidia, 70 + palpal papillae. *Male holotype*: Total length 18.0, chelicera length 4.0, chelicera width 2.3, propeltidium length 2.3, propeltidium width 3.5, palpus length 17.0, first leg length 13.0, fourth leg length 20.0. *Ratios*: A/CP 7.94, CL/CW 1.74, PL/PW 0.66, FL/FW 1.02, FW/FFW 1.70, FW/CW 6.09. *Male measurements (4)*: Total length 17.50–21.00, chelicera length 4.92–6.25, chelicera width 2.29–2.79, propeltidium length 2.17–2.83, propeltidium width 3.75–4.58, palpus length 16.5–22.0, first leg length 12.0–13.0, fourth leg length 19.5–23.0. *Ratios*: A/CP 5.94–6.78, CL/CW 2–2.42, PL/PW 0.58–0.68, FL/FW 0.79–1.06, FW/FFW 1.56–2.00, CW/FFW 6.09–8.13.

Females: Coloration as in male except the legs are lightly tinged violet at the tibia femur joint. Chelicera typical, MF with large PT, 2 IT, large AT, posterior IT in notch of PT, no cleft under AT, tiny to absent MST. Genital opercula with long, thin arms, a slightly curved interior margin ending in a lobe, wings offset, posterior margin truncate (Fig. 59).

Female measurements (5): Total length 16.0–20.5, chelicera length 4.8–5.8, chelicera width 1.8–2.4, propeltidium length 2.2–2.8, propeltidium width 3.2–4.4, palpus length 14.5–16.0, first leg length 9.5–11.0, fourth leg length 16.0–17.0. *Ratios*: A/CP 4.88–6.37, CL/CW 2.00–2.67, PL/PW 0.57–0.75, GOL/GOW 0.67–0.80.

Remarks.—*Eremobates actenidia* has only been found in the desert grass region of San Juan County, Utah. Brookhart collected from

pitfall traps set in three different habitats along a 16 km stretch of Hwy 195 in San Juan County, Utah from 29 May 2000–28 August 2000 and again on 6 June 2001. *Eremobates actenidia* was collected from desert grasslands but not from desert shrub or Piñon-Juniper assemblages in this transect. *Eremobates mormonus* is found 161 km east in Montezuma County, Colorado and *E. corpink*, new species, is found 161 km west in the Coral Pink Sand Dunes of Kane County, Utah at approximately the same latitude.

Specimens examined.—UNITED STATES: *Utah*: San Juan County, 6.4 Km N of Bluff (37°17'N, 109°33'W), 10 June–26 August 2000, Jack & Irene Brookhart in wet pitfall traps (3 ♂, 4 ♀, DMNS).

Eremobates socal new species
Figs. 10–16

Types.—Male holotype, female allotype; California, San Diego County, Mt. Palomar St. Park (33°20'N, 116°54'W), 13 July 1953, W.J. & J.W. Gertsch (AMNH).

Etymology.—A noun in apposition referring to the type locality, Southern California, as used by Jim Rome, radio and TV sports talk show host.

Diagnosis.—*Eremobates socal* can be separated from *E. zinni* and *E. mormonus* by size and shape of ctenidia, color variation and female genital operculum.

Description.—*Males*: Appendage and propeltidium background coloration dusky yellow, propeltidium violet brown on the anterior and lateral fringes, a broadly ovoid yellow center (Fig. 10), abdomen dusky grey, apical half of palpal metatarsus dusky violet, legs I & II dusky yellow, femur of legs III & IV dusky violet. Male cheliceral FF regularly curved, MF with large PT, small triangulate AT with a cleft, small IT, posterior IT separate from PT (Figs. 11–12), 47–60 palpal papillae, a few on tarsus (Fig. 13), 4 short needle like ctenidia extending less than half the succeeding segment (Fig. 14).

Male holotype: Total length 19.0, chelicera length 5.63, chelicera width 2.58, propeltidium length 2.50, propeltidium width 4.36, palpus length 18.0, first leg length 13.0, fourth leg length 21.5. *Ratios*: A/CP 6.46, CL/CW 2.18, PL/PW 0.57, FL/FW 1.00, FW/FFW 1.45, CW/FFW 5.64. *Male paratypes (4)*: Total length 19.0–20.0, chelicera length 5.00–

5.63, chelicera width 2.42–2.58, propeltidium length 2.50–2.92, propeltidium width 4.17–4.38, palpus length 16.0–18.0, first leg length 12.0–14.0, fourth leg length 20.0–21.5. *Ratios*: A/CP 6.06–6.46, CL/CW 2–2.18, PL/PW 0.62–0.7, FL/FW 0.71–1.00, FW/FFW 1.17–1.70, CW/FFW 5.00–6.00.

Females: Coloration as in the male. Chelicerae typical with posterior IT of MF in the notch, no cleft under AT (Fig. 15). No palpal papillae, no ctenidia. Genital operculum with long, broad arms, long curved medial edge ending in a point, short, offset wings, curved posterior margin (Fig. 16).

Female allotype: Total length 19.0, chelicera length 5.29, chelicera width 2.08, propeltidium length 2.29, propeltidium width 3.83, palpus length 12.0, first leg 12.0, fourth leg length 19.0. *Ratios*: A/CP 5.27, PL/PW 0.60, CL/CW 2.54, GOL/GOW 0.72. *Female paratypes* (2): Total length 20.0–20.5, chelicera length 6.25–6.50, chelicera width 2.5, propeltidium length 2.5–2.6, propeltidium width 4.50–4.58, palpus length 14.5–15.0, first leg length 12.0, fourth leg length 18.0–19.0. *Ratios*: A/CP 5.97–6.00, CL/CW 2.5, PL/PW 0.57, GOL/GOW 0.5–0.6.

Remarks.—*Eremobates social* is similar to *E. zinni* and *E. mormonus* but can be separated by the shape and size of the ctenidia, coloration, and shape of female genital opercula. It was found in the coastal shrub area on Mt. Palomar in San Diego County, California.

Specimens examined.—UNITED STATES: *California*: San Bernardino County, Big Bear Lake (34°14'N, 116°54'W), July 1950, no collector (♂, AMNH); Granite Cove, 8 Km N on Kelbaker Road (34°46'N, 115°39'W), E. Fasler (2 ♂, California State Riverside); Joshua Tree National Monument (35°07'N, 116°02'W), 22 August 1994, no collector (♀, DMNH); San Diego County, Mount Palomar State Park (now Palomar Mountain State Park) (33°20'N, 116°54'W), 13 July 1953, W.J. & J.W. Gertsch (3 ♂, ♀, AMNH).

Eremobates zinni Muma 1951

Figs. 27, 39, 50, 58

Muma 1951:58, figs. 65–68; Muma 1970:14; Muma 1987:1920.

Type.—Male holotype, female allotype from Las Vegas, Clark County (36°10'N, 115°08'W), Nevada in AMNH. Collected by Donald J. Zinn, May through August 1944.

Female paratype from Las Vegas, Clark County (36°10'N, 115°08'W), Nevada, February through June 1945 (AMNH).

Etymology.—Named for the collector Donald Zinn.

Diagnosis.—*Eremobates zinni* is closely related to *E. social* new species. It can be separated by the shape of the male chelicera, coloration, and shape of female genital opercula.

Description.—Males: Appendages dusky yellow with dusky violet brown on tarsus and distal end of metatarsus of palp, propeltidium dusky yellow with light violet tinges on anterior and anterio-lateral edges (Fig. 50). Male cheliceral FF regularly curved, MF with small triangulate AT with cleft, posterior IT separate from PT; fondal notch longer than wide (Fig. 27). Ctenidia 4 short, flat (Fig. 39), 40–80 palpal papillae.

Male holotype: Total length 21.0, chelicera length 5.7, chelicera width 2.5, propeltidium length 3.0, propeltidium width 6.4, palpus length 19.0, first leg length 15.0, fourth leg length 23.0. *Ratios*: A/CP 6.55, CL/CW 2.28, PL/PW 0.47, FL/FW 1.17, FFW/FW 1.33, CW/FFW 0.80. *Male measurements* (1): Total length 14.0, propeltidium length 3.12, propeltidium width 6.4, chelicera length 6.24, chelicera width 3.0, palpus length 12.0, first leg length 10.0, fourth leg length 16.0. *Ratios*: A/CP 4.10, CL/CW 2.08, PL/PW 0.49, FL/FW 0.90, FFW/FW 1.38, CW/FFW 1.10.

Females: Same coloration as males, MF with posterior IT in the notch of PT, AT with no cleft, genital opercula with long, thin arms, a curved medial edge ending in a point, short offset wings and a curved posterior surface (Fig. 58). *Female allotype*: Total length 23.0, propeltidium length 3.9, propeltidium width 7.0, chelicera length 4.8, chelicera width 2.5, palpus length 15.0, first leg length 13.0, fourth leg length 21.0. *Ratios*: A/CP 4.80, CL/CW 2.52, PL/PW 0.56, GOL/GOW 0.68.

Remarks.—*Eremobates zinni* and *E. ascopulatus* are sympatric at the Nevada Test Site. *Eremobates zinni* appears to be related to both *E. social* new species and *E. corpink* new species.

Specimens examined.—UNITED STATES: *Nevada*: Clark County, Las Vegas (36°10'N, 115°08'W), May–August 1944, Donald J. Zinn (♂, AMNH). *Utah*: Washington County, Saint George (37°06'N, 113°35'W), no date, no collector (♂, BYU).

Eremobates corpink new species

Figs. 20–26

Type.—Male holotype from Kane County, Utah, Coral Pink Sand Dunes (37°05'N, 112°40'W), 2 August 1988, R.W. Bauman (DMNH). Female allotype from Kane County, Utah, Coral Pink Sand Dunes, 11 June 2002, S.M. Clark (DMNS). One male paratype from Kane County, Utah, Escalante National Monument (37°25'N, 111°33'W), 9 July 2000, D.J. Craven, E. Cygen and W.N. Wendel (BYU). One male from Kane County, Utah, Coral Pink Sand Dunes, 9 July 2002, S.H. Clark and J.S. Robertson (BYU).

Diagnosis.—Separated from *E. zinni* and *E. ascopulatus* by size and shape of ctenidia, shape of female opercula and coloration.

Etymology.—A noun in apposition referring to the Coral Pink Sand Dunes, Kane County, Utah.

Description.—Males: Overall coloration pale straw yellow, palpal tarsus and distal one third of metatarsus blotched brownish violet, all other appendages pale straw yellow, propeltidium with lightly blotched brownish violet except for pale median ovoid region (Fig. 20), abdomen yellow to grey. Cheliceral fixed finger thin, regularly curved, movable finger with large PT, smaller triangulate AT, cleft anterior to AT, posterior IT separate from PT (Figs. 21–22). Two short, thin ctenidia (Fig. 24), palpal papillae 40–82 (Fig. 23). *Male holotype*: Total length 21.0, propeltidium length 2.5, propeltidium width 2.9, chelicera length 4.7, chelicera width 2.4, palpus length 16.0, first leg length 12.5, fourth leg length 22.0. *Ratios*: A/CP 6.92, PL/PW 0.90, CL/CW 1.96, FL/FW 0.56, FFW/FW 1.80, CW/FFW 12.00. *Male paratypes* (2): Total length 20.0–20.5, propeltidium length 2.60–3.82, propeltidium width 3.15–3.90, chelicera length 3.82–5.45, chelicera width 2.0–3.9, palpus length 16.0–17.5, first leg length 12.0–14.0, fourth leg length 22.0–22.5. *Ratios*: A/CP 6.22–6.94, PL/PW 0.80–0.98, CL/CW 1.32–2.60, FFW/FW 1.19–1.45, FL/FW 0.56–0.94, CW/FFW 7.96–10.70.

Female allotype: Overall coloration as in male, palpus and legs yellow, propeltidium blotched violet purple in anterior edge, abdomen grey, chelicera typical, no cleft under AT of MF, posterior IT in notch of PT of MF (Fig. 25), 2 faint violet stripes on posterior dorsal

edge of chelicera, genital opercula with short, broad arms, slightly curved medial edge with two small lobes, wings short and curved, posterior edge curved (Fig. 26). *Female allotype*: Total length 19.0, propeltidium length 2.5, propeltidium width 2.8, chelicera length 6.0, chelicera width 2.8, palpus length 15.0, first leg length 12.0, fourth leg length 20.0. *Ratios*: A/CP 5.53, CL/CW 2.15, PL/PW 0.90, GOL/GOW 0.73.

Remarks.—*Eremobates corpink* appears related to *E. zinni*. The restricted habitat in and around the Coral Pink Sand Dunes has produced other endemic species (Knisley & Hill 2001).

Specimens examined.—UNITED STATES: Utah: Kane County, Escalante National Monument (37°25'N, 111°33'W), 9 July 2000, D.J. Craven, E. Cygen, & W.N. Wendel (♂ paratype, BYU); Coral Pink Sand Dunes (37°02'N, 112°42'W), 9 July 2002, S.H. Clark & J.S. Robertson (♂ paratype, BYU).

Eremobates legalis Harvey 2002

Fig. 60

Datames geniculatus (C.L. Koch) Simon 1879:138. (Not *E. geniculatus* Simon, *sensu* Muma 1951). *Eremocosta geniculata* (Simon) Roewer 1934:570. *Eremobates legalis* Harvey 2002:451.

Type.—Female holotype from Mexico, No. 2129 (Roewer No. 9135) in MNHN

Etymology.—From the Latin “legalis” which means according to the law (Harvey 2002). The original specific epithet of “geniculatus” is from the Latin meaning bent. This origin is interesting since it probably refers to the male fixed finger and *E. geniculatus* is known only from one female.

Diagnosis.—Muma (1970) distinguishes this species by the presence of two small ctenidia but this is invalid since females of several species possess ctenidia. Female genital operculum is similar to *E. ascopulatus*.

Description.—*Female*: Overall coloration pale yellow. Palpus, legs yellow, propeltidium with faint violet tinge anteriorly. Abdomen grey. Chelicera typical, posterior tooth of MF in the notch of PT, no cleft. No palpal papillae, two tiny hair like ctenidia. Operculum with long, thin arms, smooth medial margin, short gently curving wings, posterior margin curved (Fig. 60). *Female holotype*: Total length 23.0, chelicera length 5.4, chelicera width 2.5, propeltidium length 2.3, propeltidium width 4.3,

palpus length 13.0, first leg length 10.5, fourth leg length 14.5. *Ratios:* A/CP 4.93, CL/CW 2.16, PL/PW 0.53, GOL/GOW 0.69.

Remarks.—Simon’s (1879) description of *Datames geniculatus* was of a specimen differing from Roewer’s 1934 description of *Eremocosta geniculata*. Harvey clarified this in 2002 by designating the type (Roewer No. 9135) *Eremobates legalis*. *Eremobates legal-*

is/E. geniculatus is known from the type only. Muma (pers. comm.) indicates that the other specimen in the vial is an immature. It is the only member of the scaber group presently known from Mexico (Vásquez 1981; Muma 1987). We have examined other specimens from the southwestern United States labeled *E. geniculatus* by Muma but now consider them misidentifications.

KEY TO THE MALES OF *EREMOBATES SCABER* GROUP
(Females can best be distinguished by the shape of genital opercula)

- 1. Ctenidia none or hair-like 2
Ctenidia present 3
- 2. Ctenidia absent, palpal tarsus, metatarsus brownish violet *Eremobates actenidia*
Ctenidia absent or 2 hair-like (Fig. 38), palpal tarsus and metatarsus pale
..... *Eremobates ctenidiellus*
- 3. Two ctenidia present 4
More than two ctenidia present 8
- 4. Fixed finger severely crimped in ectal view (Fig. 1); ctenidia short, thin, pointed (Fig. 42);
palpus dusky straw yellow *Eremobates scaber*
Fixed finger with no or slight crimping in ectal view; ctenidia variable; palpus variable 5
- 5. Overall coloration lemon yellow; ctenidia flat, sword-shaped (Fig. 40) ... *Eremobates hodai*
Overall coloration dusky yellow, brown or brownish violet; ctenidia not sword-shaped ... 6
- 6. Palpal color dusky yellow; posterior intermediate tooth separate from principle tooth of
movable finger; no cleft under anterior tooth of movable finger; fond length and width
equal (Fig. 35); ctenidia flat, needle-like (Fig. 43) *Eremobates ascopulatus*
Palpal color dusky yellow to brownish violet; posterior intermediate tooth in the notch of
primary tooth of movable finger; cleft under anterior tooth of movable finger; fond length
to width ratio equal or wider; ctenidia variable 7
- 7. Palpal color dusky yellow; cleft under anterior tooth of movable finger; fond length to
width ratio equal (Fig. 33); ctenidia broad, flat (Fig. 36) *Eremobates clarus*
Palpal coloration brown violet on tarsus and metatarsus; cleft under anterior tooth of mov-
able finger; fondal notch wider than long; ctenidia short, thin *Eremobates corpink*
- 8. Anterior tooth of movable finger absent or an undifferentiated ridge; fondal notch longer
than wide (Fig 5); four flat ctenidia (Fig. 7) *Eremobates icenoglei*
Anterior tooth of movable finger present; fondal notch ratio equal or wider; three or four
ctenidia, thin or flat 9
- 9. Ctenidia flat 10
Ctenidia thick, needle-like 11
- 10. Three to four ctenidia present, stiletto-like, extending half the length of succeeding sternite
(Fig. 39); palpal tarsus and distal end of metatarsus dusky; posterior intermediate tooth of
movable finger separate from principle tooth; cleft under anterior tooth of movable finger
(Fig. 27) *Eremobates zinni*
Four, flat ctenidia present (Fig. 37); palpal tarsus and metatarsus dusky amber; posterior
intermediate tooth of movable finger in notch of primary tooth; no cleft under anterior
tooth of movable finger (Fig. 29) *Eremobates mormonus*
- 11. Four to six thin, short, hair-like ctenidia present (Fig. 41); no palpal papillae; palpus brown-
ish violet on tarsus, metatarsus, tibia, and tib-fib joint; posterior intermediate tooth of
movable finger in the notch of principle tooth; no cleft under anterior tooth (Fig. 28) ...
..... *Eremobates similis*
Four, flat ctenidia present (Fig. 14); papillae present (Fig. 13); palpus dusky brown on

tarsus and metatarsus; posterior tooth separate from principle tooth of movable finger; cleft under anterior tooth of movable finger (Fig. 11) *Eremobates socai*

CLADISTIC ANALYSIS

To our knowledge, no previous cladistic analysis has been attempted for any genus or species group of Solifugae. Herein we present the first testable hypothesis of the relationships among species in the *E. scaber* species group (Fig. 61) with a member of the *Eremobates pallipes* species group, *E. pallipes* (Say 1823) set as the outgroup based on the simple structure of male chelicera and female genital opercula. Many of the ratios that are useful as diagnostic characters, are too variable to be useful as characters for cladistic analysis. We limited our cladistic analysis to characters that could be coded objectively.

The following 12 characters were used to analyze the relationships among the species in the *E. scaber* species-group (see Table 1). 1 'Propeltidium color': [0] no color, [1] color halfway down, [2] color down sides. 2 'Number of ctenidia': [0] zero, [1] two, [2] four. 3 'Ctenidia shape': [0] NA, [1] flat, [2] peg, [3] thin. 4 'Ctenidia length': [0] NA, [1] short, [2] medium, [3] long. 5 'Presence/absence palpal papillae': [0] present, [1] absent. 6 'Palpal coloration': [0] pale or dusky, [1] dark tibia and metatarsus, [2] dark tarsus, metatarsus, tibia, and femur. 7 'PIT': [0] separate, [1] in notch, [2] NA. 8 'FF crimped': [0] no crimp, [1] crimped. 9 'Cleft AT': [0] no, [1] yes, [2] NA. 10 'Size AT': [0] small, [1] large, [2] NA. 11 'GO shape': [0] smooth, [1] undulate, [2] hooked. 12 'MST': [0] medium, [1] tiny, [2] absent.

We used PAUP version 4.0 beta (Swofford 2002) to analyze the data. All characters were unordered and given equal weight. We used the branch and bound (b and b) technique to search for the most parsimonious trees resulting in one tree (Fig. 61) with a length of 38, a consistency index of 0.63 and a retention index of 0.68. Characters were then reweighted by the maximum value of the consistency indices resulting in the same tree. However, the length was reduced to 24, the consistency index was 0.68 and the retention index was 0.73. When the characters were reweighted, three characters (2, 5 & 8) had a weight of 1; six characters (1, 4, 7, 9, 10 and 11) had a weight of 0.67; two characters (3 & 12) had

a weight of 0.5; and character 6 had a weight of 0.4. Although our cladistic analysis resulted in one best tree, the relatively low consistency index and the relatively few characters deemed useful for the cladistic analysis points to the need for exploring the use of molecular markers in future phylogenetic analyses of solifugids.

DISCUSSION

Characters previously utilized by Muma, i.e. coloration, number and shape of ctenidia, number of palpal papillae, length (depth) versus width of fondal notch were valuable characters for differentiating species although statistical analysis of the FL/FW ratio character demonstrates that in several species there is more variability than Muma indicates. In addition the shape of the anterior tooth on the movable finger of the males, the presence and size of the mesal tooth and the position of the posterior intermediate tooth of the movable finger relative to the movable finger on both males and females was important. Some species also had a consistent cleft underneath the anterior tooth of the MF caused either by a depression of the dorsal edge of the FF or a slight ridge that formed anterior to the AT of the FF. Shape of male fixed finger from an ectal view was also important with some displaying an upward undulation or "crimp" and others a more normally rounded appearance. Figures 27–35 demonstrate variability and are presented for comparison purposes.

In those populations in which sufficient specimens were available for examination there was some variation in the shape and number of ctenidia but useful general criteria could be established. Some members of the same species had ctenidia that were bifid while the rest were pointed or blunt, probably because of wear. Infrequently some ctenidia were bent (see Figs. 36–43 for comparison). Some female groups displayed ctenidia but in all cases they were thin and short (Fig. 44). We did not find them to be diagnostic. We examined penultimate specimens of *E. similis* from Sevilleta LTER for ctenidia but found none. In those species in which palpal papillae are part of the diagnosis there was some var-

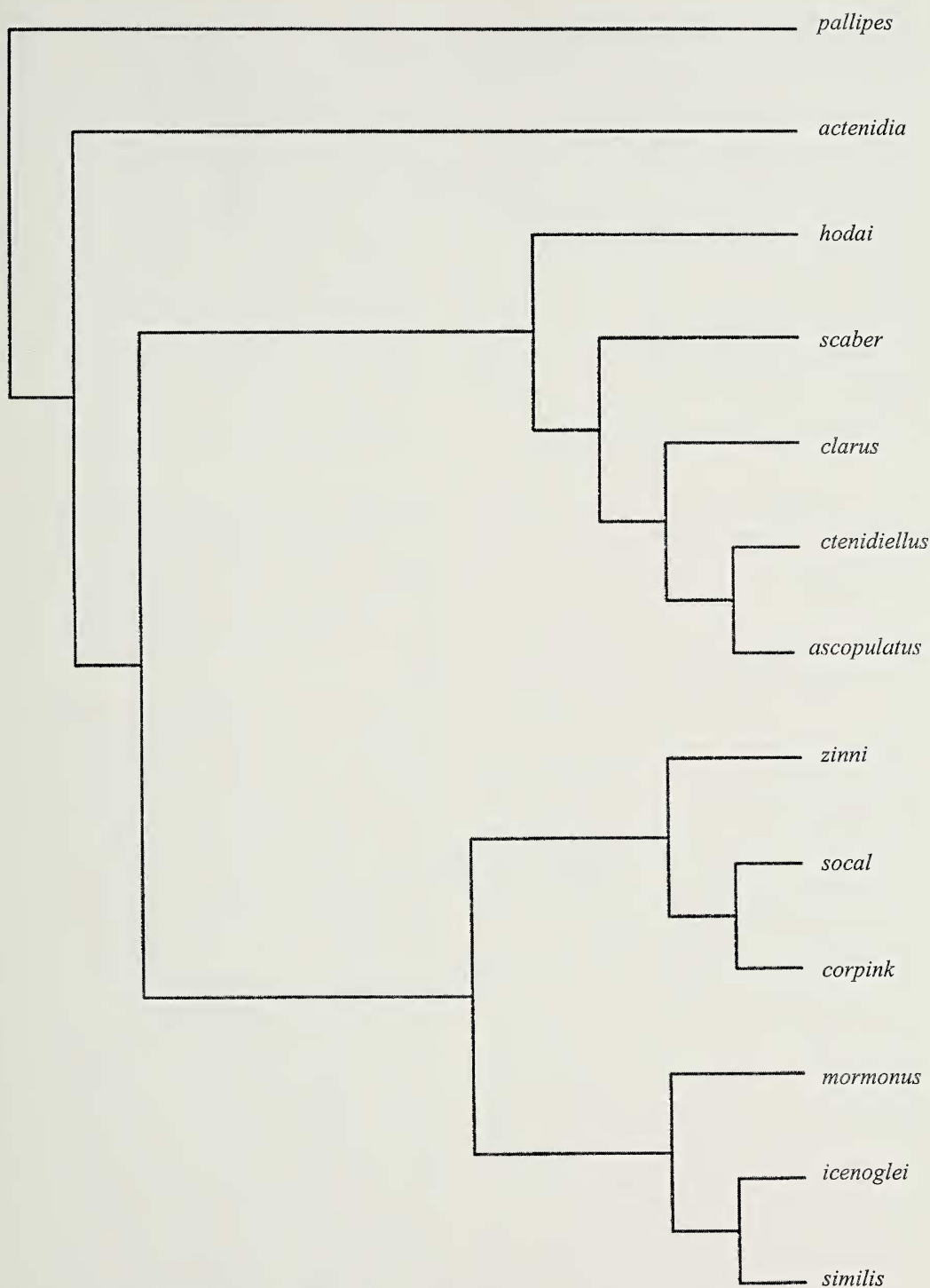


Figure 61.—Cladogram (using Paup 4.0) of the *Eremobates* species group with a length of 24, a consistency index of 0.68 and a retention index of 0.73, after character reweighting (see text for details). *Eremobates pallipes* was used as the outgroup.

Table 1.—Character matrix for species of the scaber group of the genus *Eremobates* with *E. pallipes* (Say 1823) as the outgroup. See text for description of characters.

	1	2	3	4	5	6	7	8	9	10	11	12
<i>E. pallipes</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>E. scaber</i>	2	1	1	1	0	0	0	1	0	0	1	2
<i>E. hodai</i>	1	1	1	1	0	0	0	1	0	0	1	1
<i>E. clarus</i>	2	1	2	1	0	0	0	1	1	0	1	2
<i>E. ctenidiellus</i>	2	1	3	2	0	0	1	1	0	0	0	1
<i>E. ascopulatus</i>	2	1	2	2	0	1	0	1	0	0	0	2
<i>E. zinni</i>	1	2	1	1	0	1	0	0	1	0	2	2
<i>E. socal</i>	2	2	1	1	0	1	0	0	1	0	2	1
<i>E. icenoglei</i>	1	2	2	1	1	2	2	0	2	2	2	0
<i>E. mormonus</i>	1	2	3	3	0	1	1	0	0	1	2	1
<i>E. corpink</i>	2	1	3	1	0	1	0	0	1	0	2	1
<i>E. actenidia</i>	1	0	0	0	0	1	0	0	0	1	1	1
<i>E. similis</i>	1	2	3	1	1	2	1	0	0	1	2	1

iation among the number of palpal papillae including an occasional complete absence. There is some evidence that papillae arise sequentially after the last molt.

Propeltidium coloration was also helpful in identifying several species. Many species had light brownish violet mottling on the anterior edge but several also had distinctive color patterns (see Figs. 45–51). The use of coloration in solifugids captured in pitfall traps and preserved in alcohol should be approached with caution although this trait is used in this study. Material from Hanford, Washington contained both light and dark specimens in the same vial. Solifugids collected in wet pitfall traps from San Luis Valley, Colorado changed color over a two year period (Brookhart, pers. obs.). Female coloration was almost always the same as the males. Female genital opercula were quite species specific (Figs. 52–60).

Male ratios of A/CP, FL/FW, FW/FFW proved to be statistically significant for some species. Using the Tukey-Kramer analysis of variance we found *E. similis* and *E. mormonus* to be long legged species and *E. hodai* to be a short legged species. All others showed no significant statistical difference. Only *E. icenoglei* proved to have a longer FL/FW ratio and *E. similis* and *E. mormonus* were wider. The FW/FFW ratio identifies those species with wider or thinner fixed fingers. Those with significant differences were *E. actenidia* with a thin FF and *E. clarus*, *E. icenoglei*, and *E. scaber* with wider FF. All were significant at the 95% level of confidence. PL/PW and CL/CW showed no significance. No statistically

significant character was found among any of the female ratios tested. Species vary in the position of the posterior intermediate tooth relative to the primary tooth of the movable finger and the presence or absence of a cleft anterior to the anterior tooth of the movable finger.

Brookhart & Muma (1981, 1987) and Muma & Brookhart (1988) demonstrated that solifugids are generally allopatric or in the case of the *Eremobates palpisetulosus* group sympatric for two species. Our study indicates that members of the scaber group are allopatric except *E. ascopulatus* and *E. zinni*. Our cladistic analysis seems to demonstrate a northern and a southern clade (compare the cladogram in Fig. 61 with the map in Fig. 62). Males in the northern clade have two ctenidia, a more pronounced “crimp” in the fixed finger of the male and females with either smooth or undulate medial margin of the genital operculum. Their range is larger than the southern group which has species with more endemic status. Southern males have four ctenidia, a more smoothly curved fixed finger, and females have a hooked process at the juncture of the medial margin and the wing of the genital operculum. The sympatry between *E. zinni* and *E. ascopulatus* may reflect a connection within the Lahontan Basin. We do not have enough data to indicate whether there is a temporal separation or some other process of niche partition.

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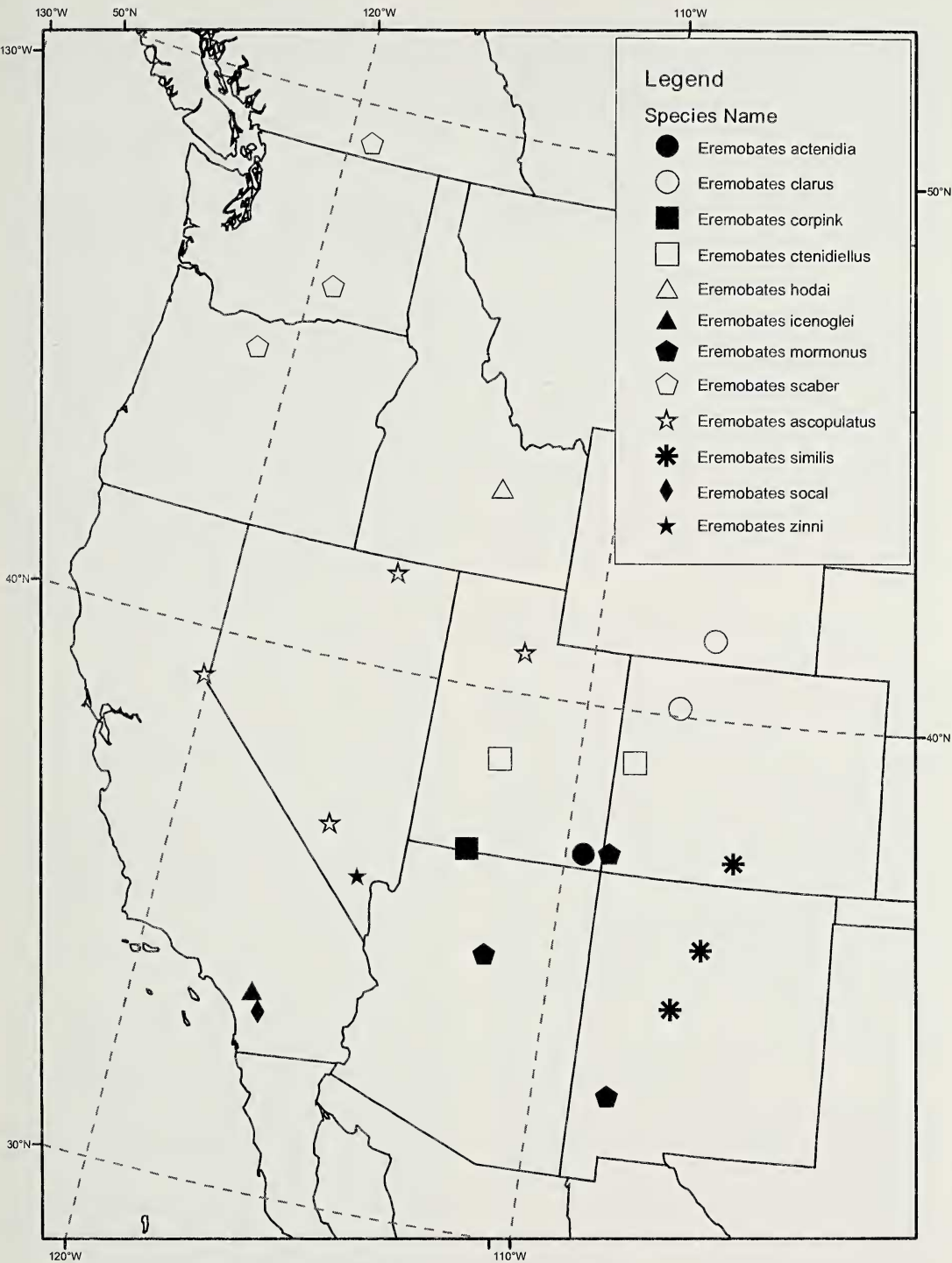


Figure 62.—Map of *Eremobates scaber* group species.

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